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Where Steam Gets 83.1 Per Cent of Heat in Fuel

PLANT OF ATLANTIC REFINING CO. EQUIPPED TO BURN OIL, COAL OR GAS; INSTRUMENTS PERMIT WEEKLY CALCULATION OF HEAT BALANCE. BY G. MILTON LEVY

ONE OF THE MOST essential things in the refining of oil is steam. It is used in the stills, in process work, in driving the many oil pumps, in supplying the plant with light and water, in keeping tanks of heavy oils at a temperature high enough to prevent solidification and in other important services too numerous to mention.

Both high pressure and low or exhaust pressure steam have their uses in changing the heavy crude oil into the many marketable products with which we are familiar.

Generation of sufficient steam to keep the oil moving from the receiving tanks to the delivery trucks loaded with finished products is in itself an enormous problem. Only by the use of miles and miles of distributing lines and numerous boiler houses is steam supplied at the proper pressure to the distant points of consumption.

In the Aug. 1, 1922, issue of this magazine there appeared a description of one of the larger houses located at the Atlantic Refining Co.'s Point Breeze plant in Philadelphia. This particular boiler house was using buckwheat coal as a fuel. In order to give the reader an idea of the wide variety of equipment for steam generation at this plant, it is only fair to describe one of the oil burning boiler houses.

This house is of modern concrete, steel and brick construction and design. It is 127 ft. long, 95 ft. wide and 65 ft. in height. The house was originally built to accommodate four Stirling three-pass boilers rated at 750 hp. each, but in 1919 it was enlarged to its present dimensions and four Stirling three-pass boilers of 750 hp. each were added.

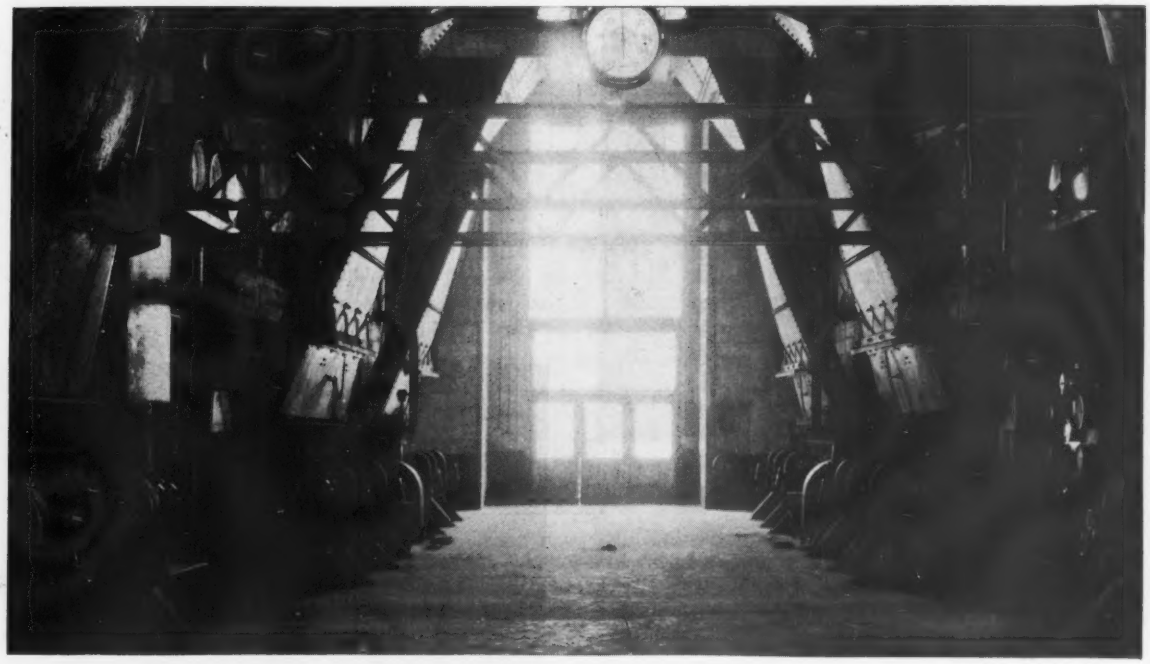


FIG. 1. COAL BURNING EQUIPMENT STANDS READY FOR USE IN THIS OIL BURNING PLANT

Each boiler has three steam drums 42 in. in diameter and one mud drum 48 in: in diameter. On boilers Nos. 1 to 4, inclusive, the steam drums are 18 ft. 8 in. long while on boilers Nos. 5 to 8 the drums are 21 ft. 3 in. long. There are 544 3¼-in. tubes ranging from 16 ft. to 20 ft. in length in each boiler giving a heating surface of 7525 sq. ft.

Boilers Nos. 1 to 4 are each equipped with four 4½-in. Ashton safety valves set to blow at 180 lb. per sq. in.; one 3-in. feed water valve; one 3-in. check valve; two 2½-in. Homestead cocks and two 2½-in. Yarway seatless blowdown valves. Boilers Nos. 5 to 8 are equipped with the same sized fittings as above but manufactured by Crane Co. These boilers are also fitted with an additional 3-in. feed line. All eight of the boilers are fitted with 7-in. Foster automatic stop valves on the steam line between the boiler and the main header.

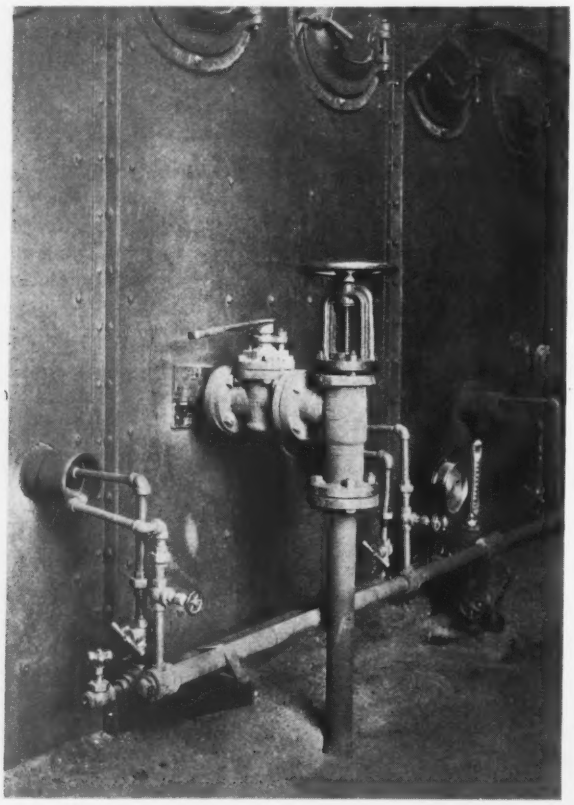


FIG. 2. PIPING TO THE OIL BURNERS ENTERS THE SETTING FROM THE REAR OF THE BOILERS

Boilers Nos. 5 to 8 are equipped with Foster superheaters, each designed to handle 22,560 lb. per hr. and raise the temperature to 440 deg. F. or furnish 75 deg. superheat. These superheaters contain 42, 2 by 6-in. U-bend elements and are of the Protected type, which do not require filling with water before starting the boilers.

Steam on leaving the boilers must pass through a dry drum where as much moisture as possible is separated out and removed by steam traps of the McDaniel type.

Sturtevant economizers are used on four of the boilers and Green economizers on the other four. The economizers are arranged in two banks, one above the other, as shown in the cross-sectional view of the house. Each economizer contains 244 4-in. tubes 11 ft. long arranged in sections of 12 tubes each; the total heating surface is 4250 sq. ft.

Coal Burning Equipment

When originally designed, the house was equipped with Taylor stokers (eight retorts on Nos. 1 to 4 and nine retorts on Nos. 5 to 8) for burning soft coal; but this fuel was used only a short time before changing to oil, which is still being used as a fuel.

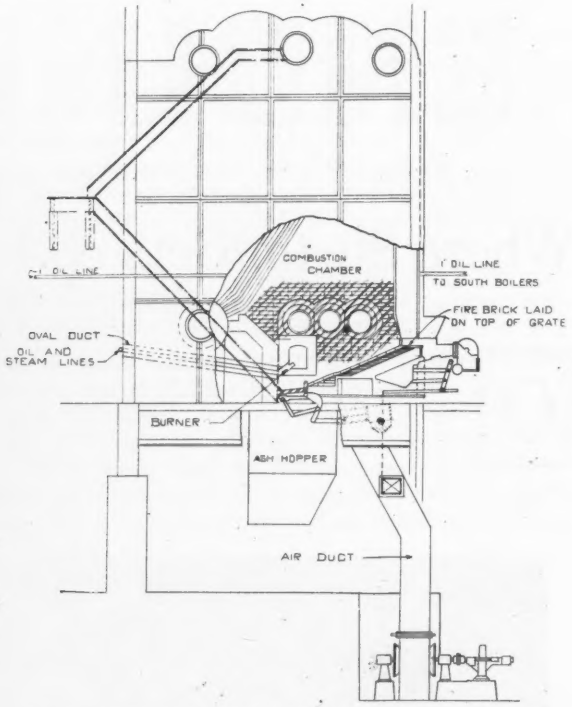


FIG. 3. FIREBRICK OVER UNDERFEED STOKER RETORTS ADAPTS FURNACE FOR OIL BURNING

These stokers are still in place and ready for use as is a well designed system of conveyors for handling coal from the cars to the bunkers, which have a capacity of 1600 T. There are two conveyors, one made by Mead-

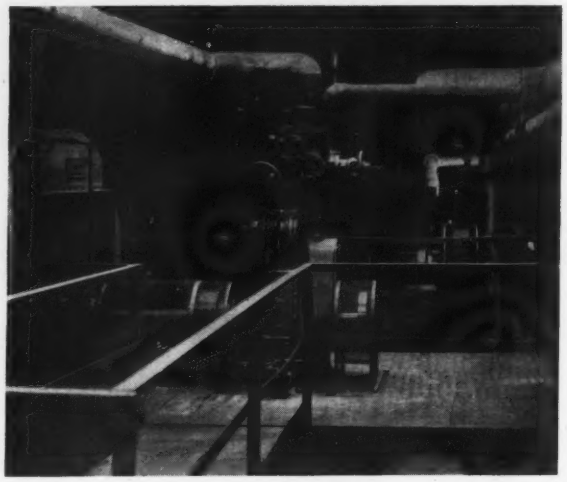


FIG. 4. ENGINE DRIVEN INDUCED DRAFT FAN MAINTAINS PROPER FURNACE DRAFT

Morrison and the other by the Link-Belt Co. A complete ash removal system was also installed, consisting of a storage battery locomotive, dump cars, skip hoist, etc., ready for use in an emergency.

Four boilers are fitted with Vulcan and four with Diamond Soot blowers. Copes feed water regulators are

installed on boilers Nos. 1 to 4 and Williams feed water controllers on Nos. 5 to 8.

There are five feed water pumps: two Wilson-Snyder, 500 g.p.m., driven by Terry turbines; one Worthington, 500 g.p.m., with Westinghouse turbine; and two DeLaval 800 g.p.m., driven by DeLaval turbines. Two Worthington duplex plunger pumps, 14 by 8½ by 13 in. and 12 by 8½ by 10 in. are used as emergency or fire pumps. There are two feed water heaters, one Cochrane

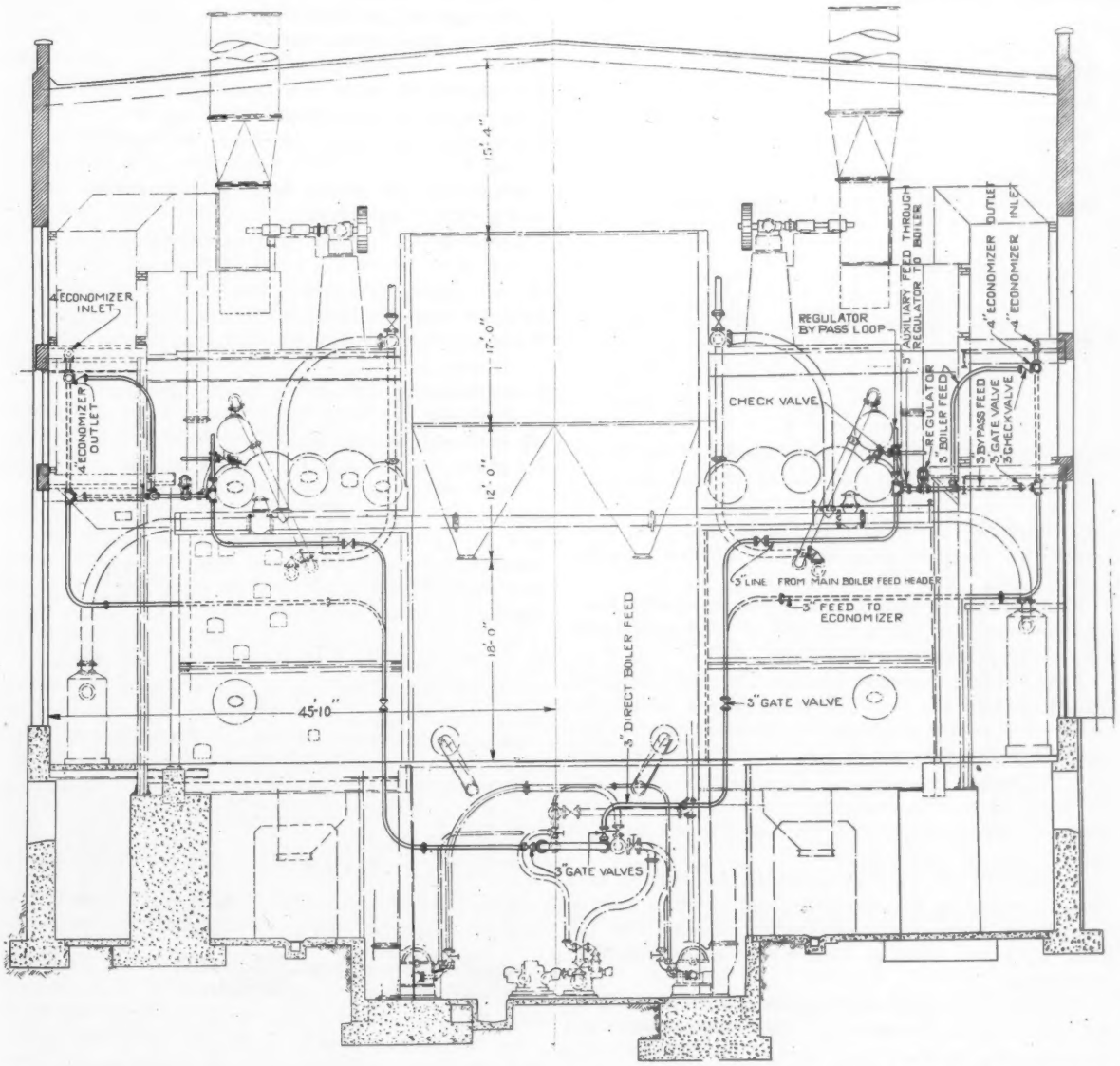


FIG. 5. SECTIONAL VIEW OF BOILER HOUSE SHOWING FEED WATER PIPING AND GENERAL ARRANGEMENT OF EQUIPMENT

400,000 lb. per hr. and one Lea-Webster 300,000 lb. per hr. capacity.

Draft is supplied by eight forced draft fans used when burning coal and eight induced draft fans. The forced draft fans are the product of the Green Fuel Economizer Co. and are driven by Terry turbines running at 2000 r.p.m maximum. Four of the induced draft fans are Sturtevant driven by Sturtevant engines and the other four are Green fans driven by Ames engines. These fans are designed to handle 55,000 cu. ft. of gas per minute at 550 deg. F. against a 3-in. water static pressure.

Burning Fuel Oil

Fuel oil is delivered once every 24 hr. to a tank located outside the boiler house; it is then pumped from this tank which contains a heating coil, through a Pratt & Cady Type C Davis heater to the burners, by three 7½ by 5 by 10-in. National Transit duplex pumps.

Oil is delivered to the burners, which are of the outside mixing type, at about 200 deg. F. and 40 lb. per sq. in. pressure. High pressure steam is used for atomization.

As can be seen from the photographs, the burners are installed in what would be the rear of the boilers. It has been necessary to cover the stokers with firebrick, also the bottom of the combustion chamber. These bricks are so arranged that they will supply air for combustion at the proper point and in sufficient quantity

to give good results. There are five burners on each of the boilers.

General Electric Co.'s recording and indicating flow meters are installed on each boiler and on each of the five lines leaving the boiler house. Another is used to measure the steam used by the oil burners for atomization.

Eight Foxboro recording thermometers are used for determining the temperature of the water leaving the economizers. The temperature of the water before and

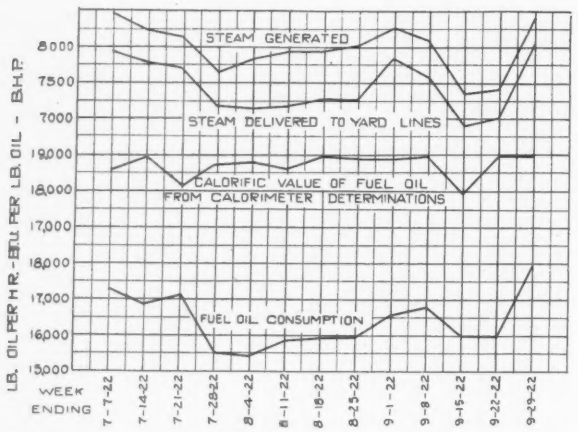


FIG. 6. VARIATION IN FUEL OIL CONSUMPTION WITH CHANGING LOAD AND HEAT VALUE OF OIL

after the feed water heater is also recorded while the quantity of water is measured by a V-notch recorder on the heater.

Flue gas temperatures before entering and after leaving the economizers are determined by a 16-point Leeds & Northrup potentiometer indicator.

Four Uehling CO_2 recorders and four Hays CO_2 and draft recorders are used for furnishing a continuous record of the carbon dioxide in the stack gases. The temperature of the superheated steam is recorded on four Foxboro thermometers. Four U-gages and four Precision, three-dial draft indicators are used. The latter are connected to the wind box, fire box and last pass of each of four boilers.

Pressure in the main steam header is recorded by a Foxboro recording pressure gage, and an 18-in. Ashton illuminated double dial pressure gage hangs over the main firing floor and can be seen in the accompanying photograph.

On the oil system there is a Foxboro recording pressure gage and a Foxboro recording thermometer, also an indicating pressure gage on the steam line to the burners at each boiler.

Miscellaneous pressure gages are located around the house where needed.

Records and Heat Distribution

Charts are changed at midnight on all the recording gages and they are carefully inspected by the operating engineer, who uses them as a guide in the operation of the house. The charts are then planimetered and the results recorded. From these records a weekly heat balance is made up. The heat balance from the oil burning house is furnished to the chief of the coal burning house and vice versa and in this way a friendly rivalry, with the resultant benefit to the power department, is fostered.

Heat distribution through the boiler house is shown by the diagram which has been made up from the average figures covering a three months' period. All quantities on this diagram are B.t.u. per hr. From this it can be seen that 79.8 per cent of the heat entering the house is delivered to the yard lines in the form of steam, and that 83.1 per cent of the total heat supplied to the boilers is delivered by them in steam.

Average performance of the boiler house over a period of time is given in the following tabulation:

Pressure, lb. per sq. in.	163
Temperature of water to heater, deg. F.	138
Temperature of water from heater, deg. F.	215
Temperature of gases entering economizer, deg. F.	620
Temperature of water leaving economizer, deg. F.	270
Temperature of gases leaving economizer, deg. F.	405
Degrees superheat (four boilers)	77.7
Steam delivered to lines, lb. per hr.	222,810
Steam delivered by boilers (without superheat), lb. per hr.	126,630
Steam delivered by boilers (with superheat), lb. per hr.	112,620
Oil consumed, lb. per hr.	16,389
Oil gravity at 60 deg. F., degrees Baumé	18.9

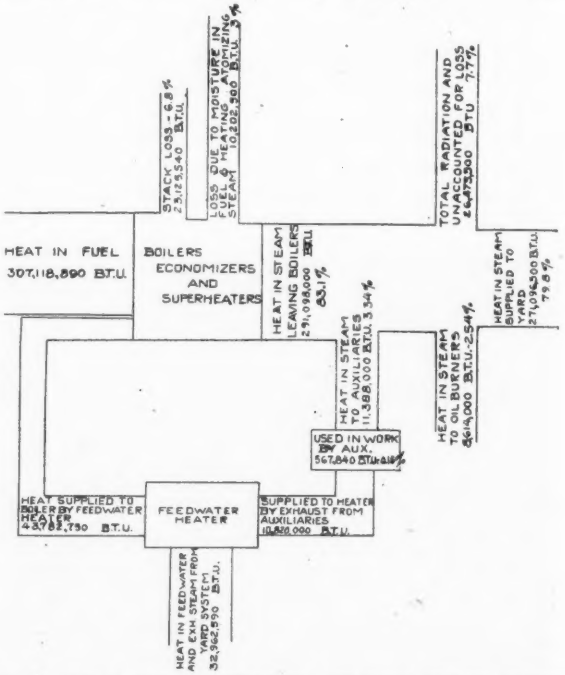

HEAT IN FUEL
307,118,890 B.T.U.
BOILERS ECONOMIZERS AND SUPERHEATERS
STACK LOSS - 6.8%
23,129,540 B.T.U.
LOSS DUE TO MOISTURE IN FUEL & HEATING ATOMIZING STEAM 10,202,960 B.T.U. 3%
HEAT IN STEAM LEAVING BOILERS 251,098,000 B.T.U. 83.1%
TOTAL RADIATION AND UNACCOUNTED FOR LOSS 24,473,300 B.T.U. 7.7%
HEAT IN STEAM SUPPLIED TO YARD 241,098,300 B.T.U. 79.8%
HEAT IN STEAM TO AUXILIARIES 11,368,100 B.T.U. 3.54%
HEAT IN STEAM TO OIL BURNERS 8,104,000 B.T.U. 2.54%
USED IN WORK BY AUX. 567,840 B.T.U. 5%
HEAT SUPPLIED TO BOILER BY FEEDWATER HEATER 48,782,730 B.T.U.
FEEDWATER HEATER
SUPPLIED TO HEATER BY EXHAUST FROM AUXILIARIES 10,800,000 B.T.U.
HEAT IN FEEDWATER AND EXH STEAM FROM YARD SYSTEM 32,562,890 B.T.U.

FIG. 7. HEAT UNITS DISTRIBUTED THROUGH BOILER HOUSE EACH HOUR OF OPERATION

Oil temperature at burners, deg. F.	190
Calorific value of oil, B.t.u., per lb.	18,710
Gas burned, cu. ft. per hr.	437
Calorific value of the gas, B.t.u. per cu. ft.	1,100
Carbon dioxide in the stack gases, per cent.	11.3
Steam supplied to the oil burners, lb. per hr.	7,080
Overall plant efficiency, per cent.	79.8
Boiler and economizer efficiency, per cent.	83.1

"Loss due to moisture in fuel and heating atomizing steam to the temperature of the stack gases" as used in the diagram is assumed constant at 3 per cent. While this is not exactly accurate, the other values give the operator a means of determining whether he is improving his performance or not and what the relative change has been during the week.

Several of the operating conditions should be noted and kept in mind when considering the house performance. The feed water used at the plant consists of raw river water which has been used for cooling the condensers of the oil stills and has become heated in this way to about 120 deg. F. The water is then treated at a central treating plant and its temperature raised again. From the treating plant the water is pumped to the boiler house where it passes through the feed water heater and the temperature raised to 215 deg. F. It is then fed to the economizer and then to the boiler.

House auxiliaries do not supply sufficient exhaust steam to heat the water in the house feed water heater to the desired temperature so it becomes necessary to draw on the yard exhaust system. The heat in this exhaust steam and the heat in the feed water entering the heater is charged to the house as is shown in the diagram of the heat distribution.

All the boilers are equipped with gas burners in addition to the oil burners but these are used only in an emergency to get rid of excess gas collected from the oil stills.

Another and very important point to be kept in mind in connection with our efficiency of 79.8 per cent is that we are not burning commercial fuel oil. Our supply consists of slop oils and very heavy bottoms which are too viscous to flow at low temperatures and must be kept hot in order that they can flow through the lines to the burners.

In order that the operating force will have a mark to "shoot at," a standard of 85 per cent overall efficiency has been set. This may seem very high, but we believe that it is a standard that can be attained only by cutting our losses to an absolute minimum, and it is to this end that all efforts are being directed.

Stoker Coal Should Be Sized

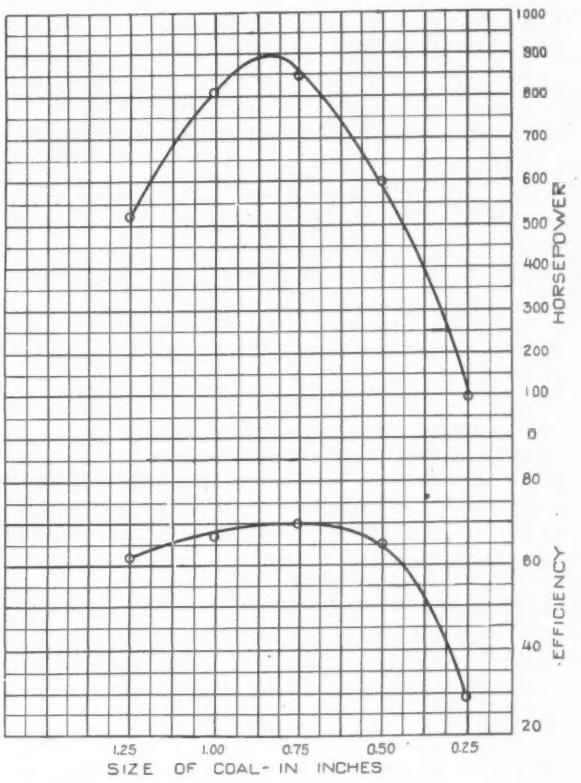
INVESTIGATIONS SHOW THAT BEST RESULTS ARE SECURED WITH COAL OF UNIFORM SIZE. BY THOMAS A. MARSH

IT WAS noticeable at the recent New York meeting of the A. S. M. E., that the main discussion of stoker papers pertained to the proper sizing of coal. It was agreed that both capacity and efficiency were quite dependent upon this item and that uniformity of size of coal over entire grate surface was even more important than that any certain size, within reasonable limits, be selected.

Usually a report of high ash pit losses brings an inquiry from the combustion engineer regarding the size of the coal. Similarly a report of irregular fires brings an inquiry regarding uniformity of coal size.

It is evident that coal should be fairly uniform in size. Assuming screenings with some pieces of coal as large as eggs and others as small as peas—certainly the smaller pieces are going to ignite and burn to a clean ash long before the larger pieces have more than partly burned. The result of this is either that a great deal of excess air goes through the fuel bed at the rear portion of the grate, or that an excess quantity of coke is discharged to the ash pit. Usually both of these effects occur, with the result that both capacity and efficiency are greatly reduced.

Proper sizing of coal and uniform sizing of coal is not a new subject. Its importance has been recognized for many years, even as far back as 1906. W. L. Abbott, chief engineer of the Commonwealth Edison Co., ran many tests and presented a paper before the Western Society of Engineers, discussing this subject in great detail. He submitted two interesting curves, so



EFFECT SIZE OF COAL HAS ON STEAM GENERATION

interesting in fact that they bear repeating in this day when ash pit losses are being watched far more closely due to higher prices of coal and where high capacities, in order to carry peaks, are of much more importance than they were in the day when Mr. Abbott made his investigations.

Results of Mr. Abbott's tests are shown in the accompanying chart, from which it will be seen that with the type of stoker involved, a chain grate, the maximum capacity was reached with coal slightly less than ¾ in. in diameter and that the best efficiency range was with coals from ½ to 1 in. in diameter, with a maximum efficiency of ¾-in. diameter.

Higher coal prices and the necessity for reducing all possible losses in recent years lead combustion engineers to a study of all losses. They realized the need of small and uniform sized coal and began to install two sets of crushers in their efforts to get their coal sizes down to a proper minimum. The crusher manufacturers

produced double crushers in which two complete crushers were incorporated in one machine. Still other manufacturers developed pulverizers which partly pulverized the coal, or at least reduced it to a uniformly fine size. In at least one instance, a Bradford rotary breaker has been installed crushing the coal by impact on the inside of a rotating cylinder, with the small size coal passing out of the openings in the circumference of the breaker. This entire situation, of course, supports the pulverized coal theory in which all coal is reduced to a very fine and uniform size and mingles with the air in the most intimate manner.

Proper coal size has been given a great deal of consideration by the Stoker Manufacturers' Association, which has defined proper size stoker coal as coal that would pass through a 1-in. round opening.

Means provided for delivering coal from the bunkers to the stoker hoppers have an important bearing on the uniformity of coal distribution. Various types of coal spreaders have been used usually with poor success due to the fact that large coal invariably works its way to the sides and the small coal feeds to the center of the stokers; also the pressure of the column of coal at the center of a spreader causes a more dense fuel bed than at the sides. Swinging chutes have the preference in most plants, but even these should be shut off by a valve in order to prevent the weight of the column of coal from causing the dense fuel bed above mentioned. In some instances, automatic swinging devices for chutes have been used with great success; another successful type of chute is the one the full width of the stoker hopper.

In attempting, therefore, to reduce ash pit losses to increase the CO_2 and to improve capacities, the combustion engineer should obtain uniformly small sized coal and should give great care to the matter of uniform distribution.

With western coals, the problem of moistening or "tempering" the coal is of equal importance. This subject will be treated in a subsequent article.

Moist Fuels Present Ash Handling Difficulties

Methods of Removing Ash, Combating Clinker Formation and Preventing Soot Accumulation on Boiler Heating Surfaces. By Zuce Kogan

CLEANING the grates and brickworks of the steam generators is done in order to keep the fuel bed and furnace conditions such as to give greatest efficiency. This is a question of economy on one hand, but on the other hand we have to consider the economy of the process, that is, how to perform the cleaning process cheaply and conveniently. With moist fuels the expense and inconvenience of the cleaning is largely increased as compared with ordinary coal, due to two important factors:

1. Notwithstanding that the fuel contains water, which usually prevents the formation of clinker, clinker does form extensively as there follows after the disassociation a union of the oxygen and hydrogen elements of the water that produces such a high temperature that clinker results in excessive quantities.

2. The furnace designed with inclined grates for the utilization of moist fuels is of such a shape that it brings forth most difficult conditions for the cleaning process.

Clinker is a more difficult problem than ashes, as it adheres rigidly to the brickwork and therefore requires chipping off. This is a difficult task and is additional to the removal (cleaning) as compared with ashes that need only to be removed. The more clinker the more labor and time required.

Considering the effect of furnace design, it may be noted from Fig. 1 that neither the grates and nor the brickwork are accessible for cleaning and these furnaces or even other furnaces with inclined grates do not permit any access to the internal parts of the combustion chamber. Even with the underground passage A we still must work from the outside or underside of the grate and are unable to perform the necessary cleaning. And yet when we come to the question of removing the excessive quantity of clinker under such conditions we get into two noteworthy troubles. First, the process of clipping off the clinker results in breaking off and damaging the furnace brickwork, thus increasing the maintenance expense. Second, when this is performed during working of boilers, the great amount of time taken due to the lack of conveniences for cleaning causes the boiler shell with its water contents and the furnace brickworks to cool down thus increase the expense of raising steam again.

Importance and Use of Underground Passages

Underground passages are of great importance with furnaces which are usually designed with long inclined grates underground, as these permit convenient attendance and inspection of furnace conditions and facilitate the handling of ashes and clinker. These underground passages are usually of two types, that of Fig. 1, A, the main passage and B, the secondary passage. These have quite different functions, so it is always an advantage to provide both.

Considering the installation of the main passage, it permits attending the grates and makes the process of chipping of the clinkers easy. Economical combustion always requires a man per grate when burning moist fuel. The reason for this is due to the great many difficulties met with in burning the moist fuel and these are as follows:

1. As with ordinary fuel and especially in the case of moist fuel which produces great quantities of clinker, the draft apertures of the grate are clogged, thus hindering the proper air supply.

2. Many moist fuels have a tendency to form in cakes, in which case the edges will burn for a short time and then go out. This may be the result of sticking of fuel, due to its water content. Moist fuel which produces much clinker on the grate will clog the draft in one or two places. This forms a large cake of fuel that burns only from its outside where the air surrounds it while inside, due to the water content and lack of air, it cannot burn. If these cakes are examined, they are usually found to have burned from outer crust, leaving the interior still unburnt. For this reason, the man

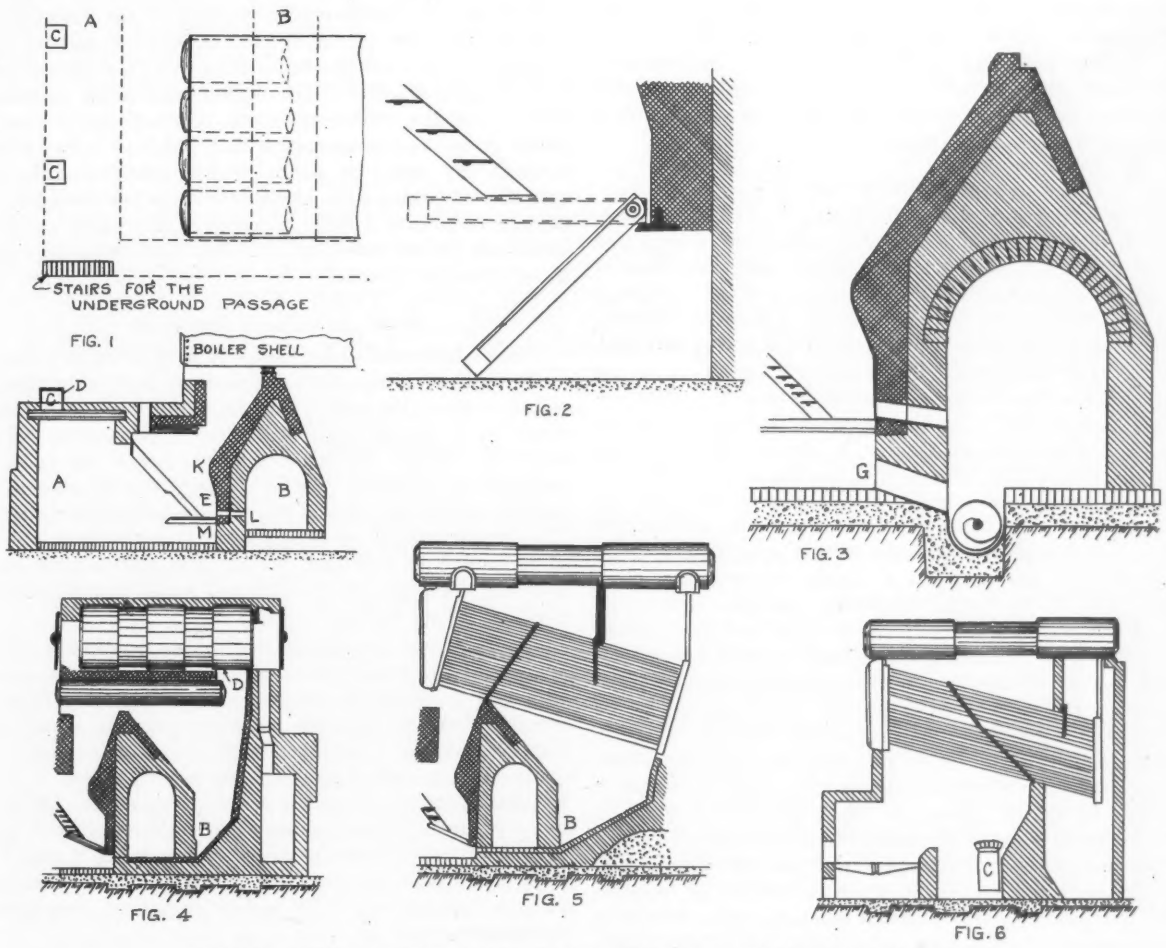
attending the grate watches through the draft doors and splits up these cakes.

3. Although the air regulators at the grates are not operated every moment, it is good practice that the furnaceman should judge from the fire conditions what adjustments to make. The reason is that with moist fuel the exact draft maintenance is not a good practice as with ordinary coal where the draft gage is the only thing to be relied upon. Here we have to regulate the draft according to the moisture content and fuel bed.

the ashes on the small grate. The removing of ashes into the secondary passage is advantageous, as it keeps the main passage clean, free from ashes and dust. This passage provides space for installing ash conveyors.

Removable and Movable Grates

As the grates stand in the way of reaching the brickwork to which the clinker adheres, it becomes necessary either to remove or move the grates so as to give easy access to the brickwork. Certainly the best pro-



FURNACE DETAILS WHICH HAVE PROVED SUCCESSFUL IN BURNING MOIST FUELS

Fig. 1. Plan and cross section of furnace for burning bagasse, showing passages for workmen. Fig. 2. Hinged grate bars that facilitate cleaning. Fig. 3. Furnace equipped with conveyor for handling ash and clinker. Fig. 4. Large combustion chamber and narrow gas passages which relieve gases of soot. Fig. 5. Water tube boiler provided with space in furnace for soot accumulation. Fig. 6. Another furnace for water tube boiler designed with soot accumulating space.

When the grates are taken apart to permit the chipping off of clinker from the brickwork walls the passage must be arranged for convenience in handling the grates, i. e., taking apart or moving these grates. The functions of the main underground passage require it to be of ample size and well ventilated for the most convenient internal working. In Fig. 1, the openings, C, C, C, which are provided for the purpose of ventilating are fitted with small chimneys 24 to 40 in. in height above the boiler room floor. The secondary underground passage permits easy cleaning of ashes. As the grate is just in front of this passage, an opening is usually made through the brickwork E which permits cleaning

cedure would be to remove the grates; but as the grates are large and heavy, it becomes impractical to do so and we have to content ourselves by removing only certain parts of the grate. For this reason, the grates used in such a furnace installation must be designed with a greater number of removable parts.

Considering now the lower or small grate, this must be taken off so that the clinker chipped off from the brickwork may fall through it right on the ground. In this case it is not absolutely essential to remove it completely and therefore it is sufficient to have the parts of movable type. Moreover, for simplicity and cheapness these grates usually consist of a few I bars which

are almost impossible to remove completely due to their being long and heavy. For all these reasons, this grate is usually arranged in a manner to slide easily to and from the brickwork. Referring to the precaution necessary to prevent breaking the brickwork when chipping off the clinker, it may be said that the closer the workman can get to the brickwork the more convenient it becomes for him to chip off the clinker, consequently the more easily the process is carried out without damage. When, however, the small grate is pulled out during the cleaning it obliges the workman to retreat back from the brickwork, thus making this arrangement impracticable. This disadvantage may be reduced by arranging the grates as shown in Fig. 2. In this case, the whole grate is made to swing on a shaft and could therefore be laid in the manner shown by the full lines for convenience in cleaning.

Conveying of Refuse

From the preceding discussion, it is easily understood that the installation of a conveying system for transporting the ashes and clinker at the same time is very difficult to accomplish. The percentage of clinker is high with moist fuels and it would be of advantage, therefore, to convey it with the ashes. But unfortunately the ashes and clinker are not obtained in the same place; the ashes when removed from the grate are deposited on side L in the secondary passage while the clinker is obtained at M, Fig. 1, just on the other side of the wall. This, therefore, necessitates a double conveying system, one for carrying the ashes and one for the clinker. For years the double conveying system was in use although it was realized that even with a large factory the installation of double conveyors is more expensive in its initial operating cost than if a single conveying system is used. Nowadays we are meeting the difficulty by making an opening G, Fig. 3, connecting the main and secondary passage, which permits pushing the clinker right into the other passage where the ashes are deposited and where the conveying machinery is usually installed. In this case, we can easily install one conveying system, a modern example of which is shown in Fig. 3, where the ashes and clinker could be transported by a single conveyor, as here of screw type. The opening G is of importance as not only does it simplify the transportation question and reduce the expense, but permits keeping the main passage clean, free from glowing clinker that annoys excessively the furnaceman.

Breaking the Clinker

Clinkers generally formed with moist fuels under certain fire conditions are of large size. These would require breaking in many instances especially when a water or steam jet ash conveyor is used. Generally it is impractical to convey these large lumps of clinker in mechanical elevators, as their size will need a larger size bucket than if ashes alone were to be carried, increasing the size of machinery, space, initial and operating expense. In any case when the importance of breaking the clinker is realized, it is usually found that unless sufficient time is given for the clinker to cool completely, the crushers as sold on the market nowadays, are impractical for this purpose. The reason is that if the clinker is still warm when thrown into the crusher, the hard paste will stick excessively to the working parts and prevent it from working properly; not only when the clinker is warm but even when cool, as the cake of clinker may seem to our conception to be already chilled because the air chills the outside surface while internally it keeps the heat a long time. It is possible to spray water on the clinker, but this is inconvenient with every boiler house, especially in this case. In order to eliminate the use of the crusher malaxators filled with water may be used instead to better advantage.

The malaxator does not crush it as the crusher does, but only breaks it through the impulse of the long arms. If the malaxator is filled with water, it cools the clinker as it is broken. Moreover the turning of the malaxator arms in the water carries the clinker with it and mixes it with the water for quicker cooling. With a malaxator it is possible to throw the clinker and ashes therein, while, when the clinker is broken into sufficiently small pieces, it can be transported with a pump or injector or through any water or steam jet ash conveyor. Moreover the malaxator with its water content has the advantage of dissolving a large percentage of soluble matter contained in the ashes and clinker and reducing the transportation expense.

Eliminating Soot Troubles

Many fuels and other refuse are of a light nature so that with a strong draft especially at high rating they will rise from the grate, and be carried along in the direction of gas flow. This is very objectionable with fire tube boilers. It seems that no means are as yet available to eliminate this completely, but the problem may be solved partially by the furnace and boiler design. The design usually consists in arranging the installation so as to compel this soot to fall into soot-pockets, decreasing the draft on the fuel bed so as to reduce the effect of lifting the fuel from the grate.

Considering the installation of soot-pockets, these are usually arranged in such a manner that the soot will tend to collect in one part of the furnace. Where possible these soot-pockets are very large as shown in Figs. 4 and 5 and arranged with one or more inclined walls so as to collect near the bottom B, where it can be easily removed from the secondary passage. When, however, no underground passages are provided with the furnace, the usual arrangement shown in Fig 6 may be of value; in this case the bottom being flat, the cleaning is done from the side of the boiler through the inspection or repairing door C.

There is no effective rule for compelling the soot to settle into these boxes. Figure 4, however, shows a design which has merit. In this case the drum containing the tubes is not in line with the lower one, but is set somewhat further to the rear end of the setting. For this reason the soot has no direct passage to the tubes, but is obstructed by the portion D of the upper drum, thus reducing the velocity through the soot-box. The furnace installation appears as a whole to close the direct passage of the gases and soot to the flues. With water tube boilers the design will depend upon the particular arrangement of baffles. To decrease the gas velocity an increase in area must be provided. The large area over the collecting boxes as shown in Figs. 4 and 5 is therefore of great help first in reducing the velocity and second in holding the soot suspended for a longer time just when the velocity is greatly reduced. The design shown in Fig. 6 is effective in this respect.

Special Slide Rule Designed to Calculate Boiler Efficiency

By C. H. S. Tupholme

FOR CALCULATING boiler efficiency a British firm of steam plant engineers has brought out a slide rule which has proved most useful. This calculator consists of two slide rules working in the usual direction and fitted into one frame. At the back of these, and working at right angles to them, is a chart engraved with lines and curves calculated from the properties of saturated and superheated steam at various pressures and temperatures; this chart is available as a complete table of total heat of steam under any required pressure and temperature and also for calculation of the degrees of superheat obtained.

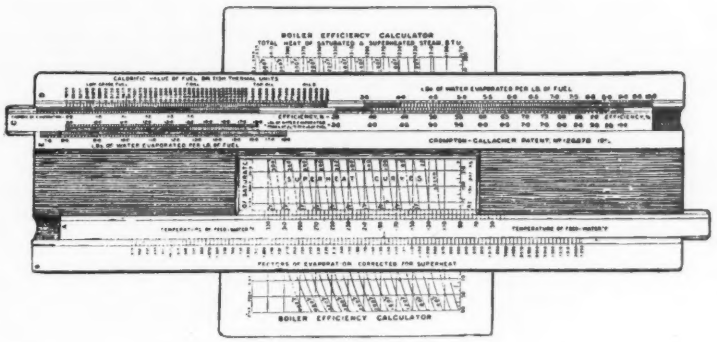


FIG. 1. CALCULATOR APPLYING SLIDE RULE METHODS TO BOILER PERFORMANCE CALCULATIONS

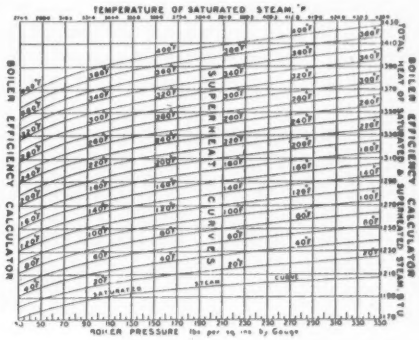


FIG. 2. TOTAL HEAT OF STEAM IS DETERMINED BY THIS CHART

Figure 1 shows the arrangement of the complete calculator with the method of division of the various scales, a photograph of the chart being shown in Fig. 2 as it appears when removed from the calculator.

Starting from the lowest one, the scales are lettered B, A, E, C and D, the alphabetical order indicating the sequence of their use in the course of ordinary calculation. A and C are moving scales and B, D and E are fixed scales. The two lower scales, B and A, are divided equally, A in values of feed water temperature in degrees F, and B in values of factors of evaporation at observed feed temperature and steam pressure and temperature.

Scales E. C and D are divided logarithmically into factors of evaporation, pounds of water evaporation per pound of fuel capacity and from and at 212 deg. F., percentage efficiency (scales C and E) calorific values in B.t.u. and pounds of water per pound of fuel (Scale D).

In order to illustrate the operation of the calculator, the following example of a boiler trial result will be worked out, the data obtained from the test readings being as follows:

Observed water evaporated per lb. of fuel consumed, lb.	8.0
Calorific value of fuel (as fired), B.t.u.	12,000
Mean feed water temperature before economizers, deg. F.	110
Mean feed water temperature after economizers, deg. F.	280
Mean steam pressure, lb. per sq. in.	150
Mean steam temperature after superheater, deg. F.	410

First, move the chart so that the horizontal line representing the steam pressure of 150 lb. per sq. in. corresponds with the upper bevelled edge of scale A. Reference to the left hand edge of the chart will show that the corresponding temperature of saturated steam at the observed pressure of 150 lb. per sq. in. is 366 deg. F. Subtraction of this from the observed steam temperature (410 deg. F.) gives a superheat of 44 deg. F. With the chart still in the same position, move slide A until the mark indicating the observed feed temperature (110 deg. F.) corresponds with the position on the superheat scale to 44 deg. F. Reference to the arrow heat engraved on the lower edge of scale A will then show that the factor of evaporation under these conditions is 1.179. Find this figure on the upper edge of scale C, which is then moved until one or other of the two arrow heads engraved on either end of scale D is opposite to the factor of evaporation. Then find the figure (8.0) denoting the observed water evaporation per pound of fuel at the right hand end of scale D, and immediately below this will be found the equivalent evaporation "from and at 212 deg F.," which is 9.42 lb. Moving scale C again until the figure 9.42 is opposite 12,000 B.t.u. on scale D, the arrow head will be found to indicate 76.2, which is the thermal efficiency of the plant as required.

Having obtained the overall efficiency of the whole plant, the efficiency of boiler and superheater without the economizer is found in exactly the same manner with the exception that the factor of evaporation is ascertained for the temperature of the feed water leaving the economizers (i.e., 280 deg. F.)

Working as before, the efficiency will be found to be 65 per cent. Subtracting 65 per cent from 76.2 per cent, we have 11.2 per cent, which indicates the added efficiency due to the economizer.

Similarly, by omitting the superheat and working to the saturation curve only at observed steam pressure, the added efficiency due to the superheater is obtained by subtraction from the total efficiency already calculated. In the example given, the total efficiency without superheat will work out at 74.5 per cent, and subtracting this from the total, 76.2 per cent, we have by difference 1.7 per cent added efficiency or heat recovery in the superheater. The total results can be stated thus:

Efficiency due to boiler only, per cent	63.3
Efficiency due to economizers, per cent	11.2
Efficiency due to superheaters, per cent	1.7
Total per cent	76.2

To use the calculator as a table of total heat of steam at various pressure, any convenient mark on scale, A, may be used as a guide and by setting this mark on the intersection point of the pressure and superheat lines on the chart and moving the latter downwards till the upper edge of the chart corresponds with the upper edge of scale A, the total heat of the superheated steam can be read off opposite to the divisions on scale A, selected as an indicator.

With a given efficiency the calculator can, of course, be used to find any other unknown quantity, such as the calorific value of the fuel used as fired or the pounds of water evaporated per pound of fuel consumed. Scale E can also be used to find the theoretical equivalent evaporation for any given calorific value of fuel up to 17,400 B.t.u.

Feed Water Temperature for Best Efficiency

ECONOMIES DETERMINED TO DEMONSTRATE THE EFFECT OF VARYING THE FEED WATER TEMPERATURE. BY LINN HELANDER*

IN POWER PLANTS using single or multi-stage feed water heaters of the condenser type, the temperature of the feed water should not be less than 150 deg. F., when using economizers, and probably not more than 260 deg. F., when not using economizers although there are conditions which permit of improved thermal efficiencies up to a temperature of 300 deg. F. corresponding to a pressure of 72 lb. per sq. in. abs. in the heater. The maximum of this range was established by a consideration of the fuel charges only. The lower limit was chosen to avoid mechanical difficulties encountered when colder water is fed to the economizers, although this temperature, 150 deg. F., is less than the lowest justified by a purely thermal analysis of the 25,000-kw. plant used as a basis for this investigation.

This investigation was for the purpose of determining the correct feed water temperatures for conditions of high thermal efficiency in a 25,000-kw. plant, with both single and multi-stage condenser heaters and with and without economizers. Two cases are considered: Case 1, where the internal Rankine cycle efficiency of the bled steam was 67 per cent, the slope of the Willans line was 12 lb. per kw.-hr. and the water rate of the main unit when carrying the total gross station load of 26,300 kw. was 70.6 lb. per kw.hr.; Case 2, where these values were respectively 80 per cent, 9 lb. per kw.-hr., and 10.26 lb. per kw.-hr. The accompanying figure shows the diagrammatic layout of the station considered. All auxiliaries as considered as motor-driven. Surface condensers were used on the main units and the condensate, before going to the feed water heaters, was passed as cooling water through the evaporator system supplying boiler feed make-up water, so long as this unit was operated on exhaust steam. When the temperature of the exhaust was too low to evaporate the water efficiently and the use of live steam became necessary, the condensate was returned directly to the feed water heater and the water for condensing the make up was taken from the feed water previously heated in the economizers or in the feed water heater. With this arrangement, the use of live steam did not materially affect the heat balance. Boiler steam pressure was taken at 350 lb. and the throttle pressure, 330 lb. The superheat in either case was 200 deg. F. The auxiliary power requirements were taken at 1300 kw. making the total 26,300 kw. At this load the steam consumption was 279,000 lb. per kw. for Case 1 and 270,000 lb. for Case 2. High pressure drips were 1000 lb. per kw. and condensate losses also 1000 lb. per kw. Low pressure radiation losses were taken at 2 per cent of the heat in the low pressure system. Boilers were operated between 175 and 200 per cent when economizers were not used and at 225 per cent with economizers. In the first instance, the boiler efficiency was 78 per cent and in the second 75 per cent, not including the economizers.

Briefly the feed water temperatures found to give the highest efficiency for various conditions of operation as regards the source of the exhaust steam and whether or not an economizer was used, are as follows:

	Deg.
I. Single Stage Heating—Case 1.	
1. Using 1600-kw. house turbine and not bleeding main unit—no economizers	210
2. 650-kw. house turbine and bleeding main unit —no economizers	220
3. 650-kw. house turbine and bleeding main unit 21,875 sq. ft. of economizer surface (50% boiler surface) heat consumption of draft fans not included	190
4. 650-kw. house turbine, 49,450-sq. ft. economizer and bleeding main unit	180
II. Double Stage Heating—Case 1.	
1. Using 1400-kw. house turbine and bleeding main unit—no economizer	280
2. 650-kw. house turbine and bleeding main unit at 2 points—no economizer	280
3. 650-kw. house turbine and bleeding main unit at 2 points—18,180 sq. ft. economizer (45% boiler area)	210–250
4. 650-kw. house turbine and bleeding main unit at 2 points, 47,000-sq. ft. economizer	180–220
III. Single Stage Heating—Case 2.	
1. Using 1700-kw. house turbine and not bleeding main unit—no economizers	190
2. 650-kw. house turbine and bleeding main unit —no economizers	200
3. 650-kw. house turbine and bleeding main unit —21,875-sq. ft. economizer	160–180
4. 650-kw. house turbine and bleeding main unit —49,450-sq. ft. economizer	160
IV. Double Stage Heating—Case 2.	
1. Using 1500-kw. house turbine and bleeding main unit for second stage—no economizer	260
2. 650-kw. house turbine and bleeding main unit at 2 points—no economizer	260
3. 650-kw. house turbine and bleeding main unit at 2 points—18,180-sq. ft. economizer	200–240
4. 650-kw. house turbine and bleeding main unit at 2 points—47,000-sq. ft. economizer	160–200

*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, New York, Dec. 4 to 7, 1922.

So many factors enter into the determination of the proper feed water temperature of a plant that figures determined for one plant should not be applied directly to another. As a general proposition, however, the temperature should be lower for plants using single-stage heating than for those using multi-stage, and also should be lower for plants equipped with economizers than for those without them. Efficiencies and water rates of auxiliary apparatus as well as the main generating units have a certain influence on the results. If the feed water temperature is raised much above 212 deg. factors incident to the use of pressure above atmospheric in the exhaust piping become of importance. The proper feed temperature is dependent somewhat upon

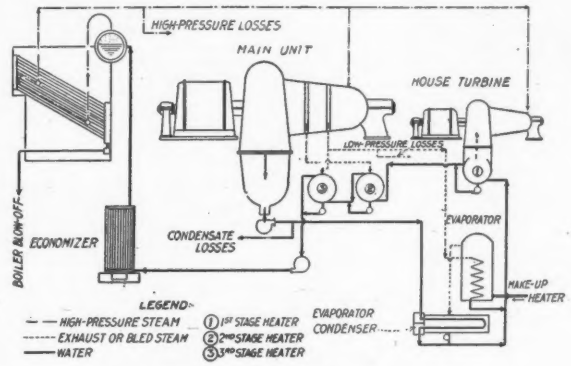


DIAGRAM OF STATION LAYOUT

the initial steam pressure and temperature and on the temperature of the condensate, increasing as these increase. It is quite impossible to determine any one feed temperature applicable to all plants; each case must be worked out on its own merits. The effort has been to indicate the effect of feed temperature on efficiency, eliminating all questions of cost except the fuel item.

Government Investigates Combustion of Waste Fuels

IN VIEW of the decreasing supply and the increasing cost of high grade fuels, the efficient utilization of fuels of low grade, including what are known as "waste fuels," is becoming a problem of major importance to many industries and to the commercial progress of the nation. Important sources of "waste fuel" enumerated by David Moffat Myers, consulting engineer of the Bureau of Mines, include sawdust, shavings, scraps, edgings, tanbark, wood-extract chips, paper-mill refuse, bagasse or spent sugar cane, and city refuse.

Perhaps the most important waste fuel in the United States has been spent tanbark, according to Mr. Myers. A rough estimate would indicate that this material generated a few years ago an amount of steam that would have otherwise required the yearly consumption of about 2,000,000 T. of high-grade coal. Yet at one time this valuable fuel was considered a mere detriment and an expense to the leather industry. It was disposed of by dumping it into rivers, by filling in waste ground, and by making roads with it, often necessitating the payment of large sums for its disposition. The improvement of a furnace converted a substance supposedly incombustible into a valuable waste fuel and an enormous waste was converted into an equally great saving.

Sawdust and wood waste are of course available mainly in lumbering districts. With sawdust the sawmills produce waste wood in the form of edgings, end cuts, shavings, and various forms of blocks and scraps. At many plants the bulk of this material is so great that it not only supplies power and heat for the mill, but furnishes electric lighting for the whole town, and even then in order to prevent its accumulation a large destructor is kept constantly in operation and the heat from the burning wood is wasted to the atmosphere. If there were a market for electric power within reasonable distance, this deplorable waste could be converted readily into a great economy. Even now plans are being considered to prevent such waste, and at least one plant is in operation for producing wood alcohol and other chemicals from such material. Inventors have long worked on plans that might make possible its use for wood pulp in the paper industry. Sawdust and wood waste are readily convertible into gas that may be used as fuel in gas engines.

Bagasse, the by-product fuel resulting from the manufacture of cane sugar, is conveyed to the boiler house, where it is fired in special furnaces and is made to produce all or part of the steam required to operate the plant. The fuel is in the form of strips 3 to 8 in. long, but much longer pieces may sometimes come through the mills. There is much room for improvement in the design and in the control of furnaces in many plants burning bagasse; these two factors often make the difference between running the boiler plant on very little or no purchased fuel and of spending large sums annually for coal, oil, or wood.

When gas is made by the destructive distillation of soft coal, which is the older method employed at city gas works, a finely divided coke known as coke breeze is left as one of the important by-products. As the volatile gases have been driven off, the coke is mainly carbon, which is naturally higher in ash than the coal. The particles of coke are about the size of No. 2 or No. 3 Buckwheat coal, and can be used successfully as a boiler fuel with proper furnace equipment. Coke breeze can compete with the fine sizes of low-priced anthracite coal.

City refuse belongs to the class of fuels that, by proper application of the principles of combustion, have been promoted from semi-combustible to autocombustible fuel. Though this heterogeneous material can be disposed of by dumping at sea or on waste land—sometimes in an inexpensive manner—the consensus of opinion is strongly in favor of its disposition by burning. The strength of this opinion is largely due to comparatively recent improvements made in the design and efficiency of destructors or refuse burners.

It is a notable achievement of engineering study and skill that has made possible not only the smokeless and complete combustion of city refuse but also the production of useful heat and power from this former waste.

So important is the economic combustion of waste fuels to the industry of the country that a special investigation has been conducted by the government, the results of which are contained in Technical Paper 279, which may be obtained from the Bureau of Mines, Washington, D. C.

Novel Features of Surge Tank Pit River Power Plant No. 1

Surge chamber for the Pit River Power Plant No. 1. Before constructing this chamber the engineers found it necessary to build a model to determine the amount of surge and also the stresses involved, owing to the fact that no such chamber had ever been built and that therefore they were without a precedent. The chamber is 60 ft. in diameter at the top and is provided with steel flash boards and walkway extending entirely around it. The collecting chute is formed by a concrete wall around the chamber and 6 ft. from it, as found necessary from a study of the model. Ten carloads of steel reinforcing and 30 by 36 in. I-beams, made especially for the purpose, were used in the construction of the chamber and flashing.

One thousand second feet of water from the surge chamber falling over a 400 ft. cliff. Note the lack of turbulence in the overflow channel.

Penstocks and anchor supports. In the valve house in the bakground are the largest butterfly valves in the world, being 10 ft. 9 in. in diameter.

How the Wygodsky Oil Engine Operates

AIRLESS ATOMIZER, IGNITION ELEMENT, FUEL OIL TORCH, AIR FOOT PUMP AND FLYWHEEL LOCKING USED FOR STARTING

ONE feature of particular interest in the Wygodsky crude oil engine is the method of starting which does not require the use of compressed air. This engine operates with a compression of 300 lb. and is therefore classified in that group known as low compression or semi-Diesel types.

Such engines require some special method of starting as heavy oil will not ignite in the presence of air at the temperature created by this low compression. If, however, the oil strikes a hot surface, it will break up into hydro-carbons which will ignite at a lower temperature. Several methods such as electrical, hot bulb and hot pin are used to secure this action.

In the Wygodsky system, the method of securing this ignition for starting has been worked out by using an ignition element, a fuel oil torch, an air foot pump and a flywheel locking device.

When it is desired to start the engine, the foot pump, in Fig. 2, is given several strokes and the torch is ignited by a lighted match, the pumping being continued for about 2 min., in the course of which time the ignition tube becomes hot enough to ignite the spray. After the

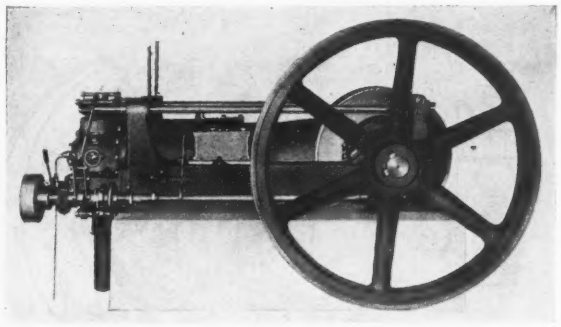


FIG. 1. LOW COMPRESSION CRUDE OIL ENGINE HAS SELF STARTING FEATURE

ignition device has been made hot enough, some of the air from the foot pump is admitted into the combustion chamber with the double purpose of making sure that the combustion chamber is filled with pure air and also to have the air pressure raised to 40 lb. The spring of the above-mentioned locking device is made strong enough to hold the flywheel in the starting position so that the flywheel will not be released until there is enough pressure behind the piston to start the engine running. This pressure is produced by manually operating the fuel pump. This action produces a spray through the atomizer into the combustion chamber. As this spray is produced in the proximity of the ignition tube and in an atmosphere of 40 lb. pressure, an explosion follows which is strong enough to turn the dog of the locking device. This locking device then collapses and the engine begins to work normally. The torch then goes out by itself, and the lubrication starts automatically so that no valves have to be operated.

In this engine the starting cycle gives a mean effective pressure above 100 lb. per sq. in., so that the engine starts with a load of approximately 50 per cent of its rated capacity. The engine is also provided with means for self cleaning. By means of a special device the engine ejects automatically any solid or liquid deposit that may find its way into the combustion chamber and

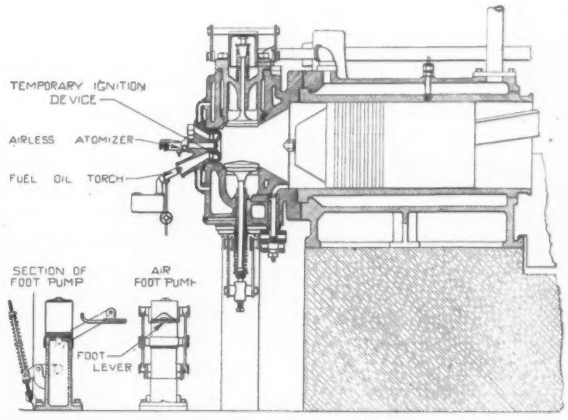


FIG. 2. FIRST INJECTION TAKES PLACE AT 40 LB. PRESSURE WHICH IS CREATED BY AIR FOOT PUMP

the same feature is utilized for stopping the engine approximately in its starting position.

An airless atomizer, as shown in Fig. 3, produces the atomization of the fuel by hydraulic pressure which is developed by means of a fuel pump, which is under direct action and control of the governor. The principal part of the atomizer is a spray cone, the conical surface of which is covered with spiral grooves of diminishing sections and is placed against a similar conical surface

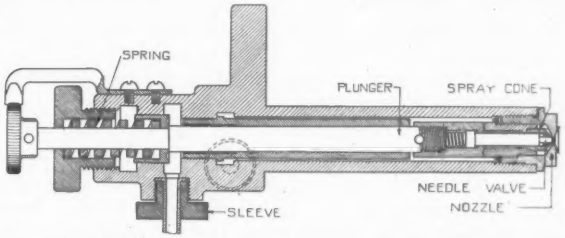


FIG. 3. MECHANICAL ATOMIZATION IS PRODUCED BY PRESSURE OF OIL

in the nozzle. The throat of this nozzle is closed by a needle valve, which is movable in conjunction with a plunger. This plunger has a snug fit in the sleeve, and is loaded by means of a spring. The pressure of the oil within the atomizer due to the action of the fuel pump, will move the plunger against the spring and will carry along the needle valve, thus opening the nozzle. Oil will then circulate through the spiral grooves of the spray cone, with accelerating motion due to the decreasing sections of the spiral grooves, and will set up in the throat of the nozzle a small column of oil in high rotary motion. This column when released from the nozzle breaks up into a very fine mist due to centrifugal action. As soon as the fuel pump plunger stops advancing, the pressure

in the sprayer drops instantly and the spring shuts the nozzle rapidly and prevents dribbling.

Such an arrangement permits the breaking up of the smallest quantities of oil into a fine mist without any dribbling. To give any idea of the effectiveness of the spray, it may be mentioned that the column of oil in the throat of the nozzle produces about 1,100,000 r.p.m. and the initial velocity of the particles of oil which issue from the nozzle is about 270 ft. per sec. Any fuel, even with a high flash point, easily ignites when cold if atomized by means of this sprayer.

As previously mentioned, the engine works with a moderate compression of 300 lb. per sq. in., and to obtain

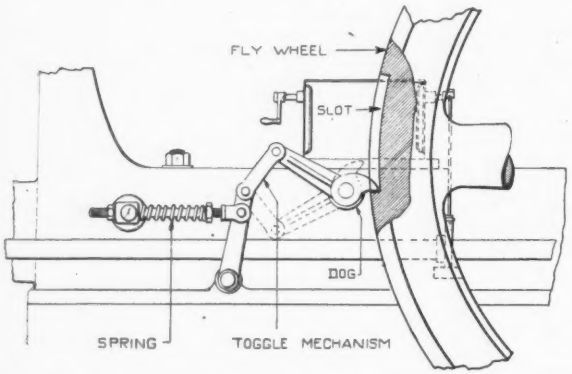


FIG. 4. FLYWHEEL LOCKING DEVICE WHICH IS USED FOR STARTING ENGINE

the starting ignition while the engine is cold, a temporary ignition device is used. This ignition device is a hollow ring which is totally enclosed within the water cooled combustion chamber. No hot surfaces are exposed to the outside of the engine as the heated surfaces are entirely inside the combustion chamber, so it is evident that this is not a hot bulb engine. The device has two apertures which connect the inside of this hollow ring with two channels in the water-jacketed cover projecting through the cylinder head. One channel is for the introduction of the oil torch and the other channel serves for the escape of the products of combustion.

This torch is connected to the foot-air-pump of an interesting construction, which furnishes the air to the torch. The torch can burn the same fuel as the engine and the reservoir can be refilled while the torch is burning as there is no pressure on the oil whatever. The torch does not require any preheating for it to start to burn as soon as the foot pump develops 25 lb. pressure in a reservoir of about 3½ gal. capacity.

In Fig. 4 are shown the details of the flywheel locking device. This locking mechanism consists of a toggle which is pivoted in two points and loaded by means of a spring. The position of this mechanism as shown in Fig. 4, is that taken when the engine is ready for starting with the dog inserted in the slot of the flywheel. This keeps the flywheel in starting position, in which position the crankshaft is about 60 deg. above its inner dead center on the firing stroke.

Governing in this engine is of the variable stroke type and timing of the beginning of injection is made constant and the end of the injection is variable, i. e., sooner or later according to the load on the engine. The governor consists of a governor proper, as well as the governing mechanism, all enclosed in one casing. The governor and pump are represented in Fig. 5, in which the plunger, suction valve, and delivery valves are shown. The governing mechanism consists of a cam lever which is pivoted eccentrically in the governor casing. This lever is provided with a cam face which acts directly on a roller of the fuel pump. This cam face is an arc of a circle described from its pivot center and the position of this cam lever is determined by means of a finger which is attached to a swinging pivoted lever. This finger acts between a special inner face of the governor case and a curved face of the cam lever; the inner face of the case is an arc of a circle described and the curve of the cam lever is figured out so that the tangents of these two curves and finger form an angle which is less than the angle of friction corresponding to the material used. The idea is that when the governor runs in a counter-clockwise direction the reaction from the roller on the cam lever tends to jam the finger without pushing it in either direction. It should be mentioned that the link is connected to one of the governor weights. There is also another governor weight which is situated in a diametrically opposite position and is connected in such a manner as to give both weights a similar motion. These two weights furnish the centrifugal force of the governor and the centripetal force is furnished by spring

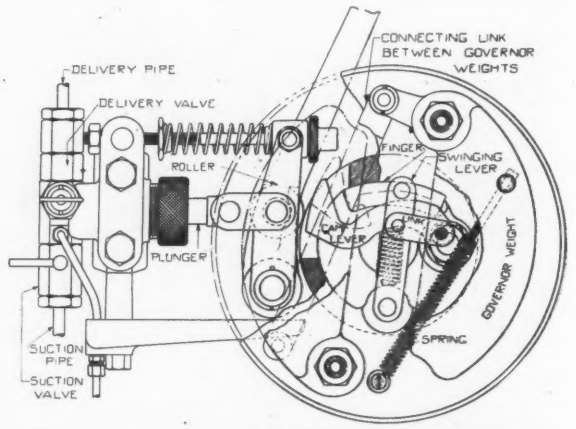


FIG. 5. WITH THIS GOVERNOR BEGINNING OF INJECTION IS CONSTANT BUT END OF INJECTION PERIOD IS VARIABLE

which is arranged to permit an adjustment of its length, as well as an adjustment of its tension. As mentioned before, the finger being situated in an angle which is less than the friction angle it will not transmit any reaction to the weights of the governor. The cam face of the governor lever, being an arc of a circle will have the same point of intersection with the outer periphery of the governor casing irrespective of the position of the cam lever. This naturally will give a constant point for the beginning of the injection of the fuel.

Both the four-cycle horizontal type for stationary service as shown in Fig. 1 and a two-cycle engine for both stationary and marine service are built using the same general features of design.

In the two-cycle type, a modified opposed piston principle is used. Both pistons are operated from an angle in a common combustion chamber, which permits the use of the same mechanism for the introduction of fuel. As will be noted from the sectional view shown

in Fig. 6 two crank shafts are used, an upper and a lower one. They are connected by means of a special link motion so that they operate in synchronism and in opposite sense. Each crankpin is operated by two connecting rods; and the upper and lower pistons work symmetrically. Owing to the peculiar shape of the cylinder structure, an engine of this construction is known as the diamond type.

Two double-acting scavenging pumps are connected by means of tubular members to the two air manifolds into which these two pumps discharge the air. The four pistons of these pumps are operated by means of four crankpins, two of which are located in each of the two crankshafts respectively. The same crankpins are utilized for the link mechanism which connects both crankshafts so as to make them operate in opposite directions; thus the crankpins serve a double purpose, i. e., the operating of the four pistons of the scavenging pumps as well as the connecting mechanism between the two crankshafts. Owing to automatic air valves of a special construction, these same scavenging pumps serve also for starting and reversing the engine by means of compressed air when this feature is desired. The different parts of the pump are connected by means of pipes to the air distributing mechanism which is actuated by means of a hand lever. This hand lever, when pushed backward, starts the engine in a backward or reverse direction and when pushed forward starts the engine in a forward direction. When left alone, the lever automatically returns to its neutral position and automatically cuts off the air supply from the tank.

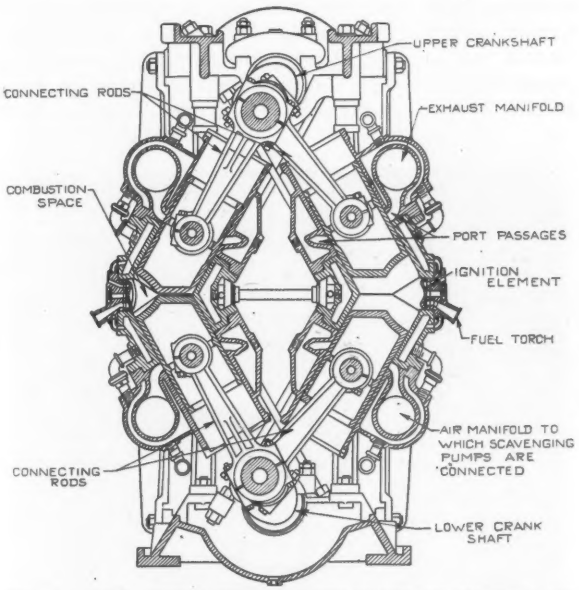


FIG. 6. TWO CYCLE ENGINE USES MODIFIED OPPOSED PISTON PRINCIPLE

Movement of the hand lever has the effect of automatically converting the scavenging pumps into working cylinders directing the air into the necessary chambers to effect the movement of the pistons in the desired direction and finally exhausting expanded air into any of the working cylinders, scavenging it through the usual ports. After that the air escapes through the regular exhaust pipe. This system of utilizing the compressed air has the advantage of securing pure air for the combustion and also does away with the necessity of providing extra muffles to take care of the air exhaust.

These two-cycle engines have been built by the Baltimore Oil Engine Co. in 1000-hp. units which are made in four sections. It is said that a 10,000-hp. engine can be built by adding sections; although the piston speed is only 750 ft. per min., it is stated that this type of two-cycle engine weighs only 35 lb. per b.hp.

Largest Testing Machine in the World

WHAT IS probably the largest testing machine in the world is now being installed in the main laboratory of the Bureau of Standards at Washington, D. C. This machine, which has been in use for several years at a branch laboratory in Pittsburgh but which has recently been moved to Washington, is capable of exerting a crushing force equal to the weight of 50 loaded coal cars of 100 T. each.

When erection has been completed and adjusted, it will be used to test the specimens for the towers of the Delaware River bridge, now under construction at Philadelphia, and will then be used on the remainder of 72 steel columns which were being tested at Pittsburgh. It has recently been used for tests on 45 samples of brick wall laid in different ways and with different kinds of mortar.

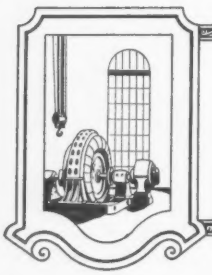
This machine has two massive heads, one set in a concrete foundation beneath the laboratory floor, the other supported on four steel screws, each over a foot in diameter, and two stories high. The upper head may be set at any height by turning the nuts on the screws by means of an electric motor.

In the operation of the machine, the specimen to be tested is placed in the machine by an electric crane of 20 T. capacity. The upper head is brought down until it rests on the specimen and the load applied by a huge hydraulic jack built into the lower head. The piston of this jack, on which the specimen rests, is lifted by oil forced into the cylinder under a pressure of 5000 lb. per sq. in. by a motor-driven pump.

Measurements are usually made of the shortening of the column under load, and when it crushes the broken pieces are studied to find the reasons for the failure and the method for making stronger columns.

Long columns are the most difficult of all engineering structures to design. No reliable means has yet been worked out for calculating their strength in advance from the unit strength of the material. This can be done with a rod in tension; 10 ropes will carry 10 times as much as one rope, and a bar of iron 2 in. by 5 will carry 10 times as much load in tension as a bar 1 in. square—provided the material is the same throughout. But with a column in compression this is not true; the strength depends much more on the shape and size of the part than it does on the amount of material in it, so the only way to be sure the column is strong enough is to test the full sized part in a testing machine such as this.

Such tests result in a great saving of money. Once a column has been tested, the load that can safely be carried by a column of the same size and type is known, and all such columns built thereafter can be loaded to their safe working load without fear that they will fail.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Instrument Transformers for Power Circuits---II

General Considerations Regarding Current Transformers. By J. B. Gibbs*

CURRENT TRANSFORMERS are used wherever the current to be measured is too large for commercial instruments, and wherever the voltage is high enough to be dangerous. They serve, as explained before, to deliver to the instruments a certain definite fraction of the current which it is desired to measure. They are used with ammeters, wattmeters, watthour meters, power factor meters, relays, and trip coils for circuit breakers.

Figures 1, 2, 3 and 4 show several forms of current transformers. Those for low voltages are usually made

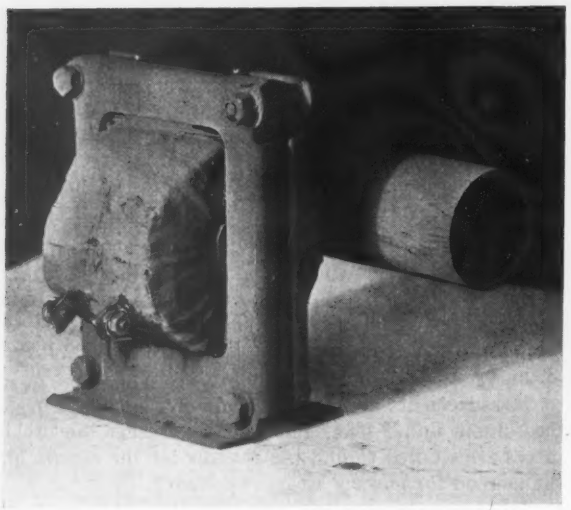


FIG. 1. CURRENT TRANSFORMER, 2300 V. CLASS

FIG. 2. THROUGH TYPE CURRENT TRANSFORMER

for operation without oil, while those for high voltages are oil immersed. In Fig. 2 is shown a form known as the through type. It is used especially where large currents at reasonably low voltages are to be measured. It has no primary conductor, but a cable or bus bar of the main circuit runs directly through a hole in the current transformer and forms the primary winding. This type is not suitable for use with small currents if accurate measurements are desired. It is used, however, for tripping circuit breakers with currents as low as 50 amp.

Of the current which passes through the primary of current transformers, a part is reproduced in the secondary winding, and a part is used in magnetizing the iron core. Since the magnetization curve of the iron is not a straight line, the proportion of the primary ampere turns used in magnetizing the iron varies as the primary current varies. The ratio of the current transformer, therefore, varies with the primary current. The ratio usually increases as the primary current decreases. For the same reason, the phase angle of the current transformer changes with the primary current.

Figures 5 and 6 show typical current transformer curves. It will be noted that increased secondary load causes an increase in ratio. This is what would be expected. The larger secondary load requires a larger secondary voltage. This requires a higher magnetic density in the iron and a larger magnetizing current, leaving less of the primary current to be reproduced in the secondary.

Current transformer load is usually expressed in volt amperes at 5 amp. A change in the current causes a corresponding change in the actual volt amperes delivered by the current transformer to a given impedance. It may seem more logical, therefore, to specify the load in terms of its impedance. However, the term "volt-

*Transformer Engineer, Westinghouse Electric & Mfg. Co.

ampere load'' does not cause confusion if it is remembered that it is always understood to be at 5 amp.

Example. An ammeter connected to the secondary of a 750 to 5-amp. current transformer with the characteristics shown in Fig. 5 reads 500 amp. Correct this reading for the ratio error of the current transformer. The total load on the current transformer secondary is 10-v.-amp. at 80 per cent power factor.

Solution. 500 amp. in $\frac{500}{750}$, or 66⅔ per cent of the rated current of the transformer. From the curve, Fig. 5, the ratio at this current and the specified load

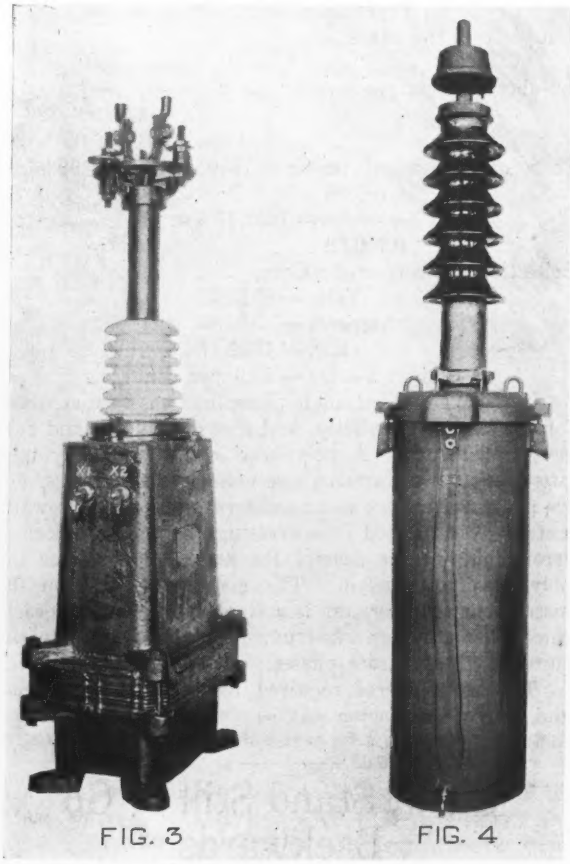


FIG. 3 FIG. 4

FIG. 3. INDOOR TYPE CURRENT TRANSFORMER 23,000 V. CLASS

FIG. 4. OUTDOOR TYPE CURRENT TRANSFORMER 66,000 V. CLASS

is 99.95 per cent (ratio curve No. 2). This is the factor by which the reading must be multiplied to correct for the ratio error. The corrected reading, therefore, is

$$500 \times 99.95 \text{ per cent} = 499.75 \text{ amp.}$$

If current transformers are used with wattmeters, the phase angle must be taken into account. In Fig. 7, OE and OI represent the voltage and current in the circuit to be measured. The true power is OE × OI × cos a. If the current transformer delivers to the meter the current OI′ instead of OI the wattmeter reading will be OE × OI′ cos (a — b), and to correct this reading for the effect of the current transformer, it must be multiplied by $\frac{OI \cos a}{OI' \cos (a - b)}$, that is

$$\text{True watts} = \text{wattmeter reading} \times k \frac{\cos a}{\cos (a - b)}$$

$$\text{where } k = \frac{OI}{OI'}$$

The angle b is positive when the secondary of the current transformer leads the primary. This is the usual condition.

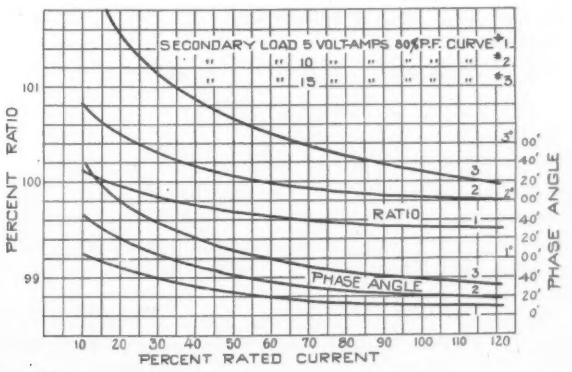


FIG. 5. RATIO AND PHASE ANGLE CURVES OF CURRENT TRANSFORMER 2300 V., 60 CYCLES

Example. An ammeter reads 600 amp., and a wattmeter reads 3300 kw. They are connected to the secondary of a 750 to 5-amp., 6900-v. current transformer. The total load on the current transformer is 25 v.-amp. at 80 per cent P.F. The voltage of the circuit is 6600. Correct the readings for the errors of the current transformer.

Solution. From the curve, Fig. 6, the ratio at $\frac{600}{750}$ = 80 per cent of rated current is 100.00 per cent (see ratio curve No. 3).

Therefore, the current reading is correct = 600 amp.

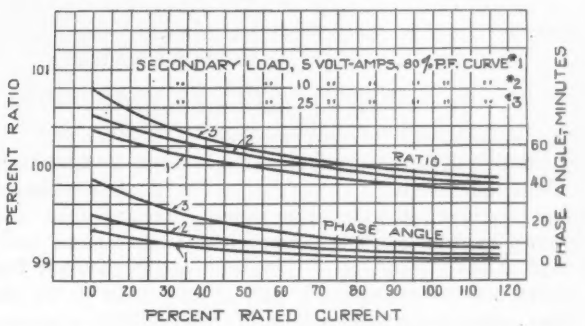

SECONDARY LOAD, 5 VOLT-AMPS, 80% P.F. CURVE *1
" " 10 " " " " " " *2
" " 25 " " " " " " *3
PERCENT RATIO
PHASE ANGLE, MINUTES
RATIO
PHASE ANGLE
PERCENT RATED CURRENT

FIG. 6. RATIO AND PHASE ANGLE CURVES OF CURRENT TRANSFORMER 6900 V., 60 CYCLES

Since the readings are taken on the secondary of the current transformer, they correspond to OE × OI′ cos (a — b), Fig. 7.

$$\cos (a - b) = \frac{3300 \times 1000}{600 \times 6600} = 0.833,33$$

$$a - b = 33^\circ\ 33'\ 26''$$

From the curve, Fig. 6, $b = 11'$

Adding, $a = 33^\circ\ 44'\ 26''$

$\cos a = .83156$

and the true power $= 3300 \times 100.00$ per cent $\times \dfrac{0.831{,}56}{0.833{,}33} = 3293$ kw.

When both current and voltage transformers are used with a wattmeter, the reading will be affected by the errors of both transformers. In Fig. 8, E and I represent the true voltage and current in the power circuit, while E′ and I′ represent the voltage and current

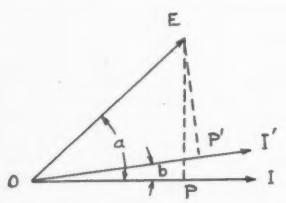


FIG. 7

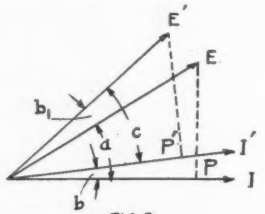


FIG. 8

FIG. 7. VECTOR DIAGRAM OF CURRENT AND VOLTAGE RELATIONS IN CIRCUIT TO BE MEASURED

FIG. 8. CURRENT AND VOLTAGE RELATIONS IN POWER CIRCUIT AND IN SECONDARY CIRCUIT OF TRANSFORMERS

delivered by the secondaries of the instrument transformers. From the diagram (Fig. 8)

True power $= E\ I \cos a$

and Wattmeter reading $= E'\ I' \cos c$

$= E'\ i' \cos (a + b_1 - b)$

To make this equal the true power, it must be multiplied by

$$\frac{E\ I \cos a}{E'\ i' \cos (a + b_1 - b)}$$

But $\dfrac{E}{E'}$ we have called K′, the per cent ratio of the voltage transformer, and $\dfrac{I}{I'}$ we have called K the per cent ratio of the current transformer.

Therefore, true power = wattmeter reading $\times$

$$K'\,K \frac{\cos a}{\cos (a + b_1 - b)}$$

Example. A power system uses voltage transformers whose characteristics are shown in Fig. 5 (Jan. 1 issue), and current transformers whose characteristics are shown by Fig. 6. The voltage transformer has a total load of 60 v.-amp. at 60 per cent power factor. The current transformer has a load of 10 v.-amp. at 80 per cent power factor, and a ratio of 500:5. With a certain load on the system, the readings are as follows:

Voltmeter ..... 6900 v.
Ammeter ..... 350 amp.
Wattmeter ..... 1650 kw.

Correct these readings for the transformer errors.

Solution—350 amp. is $\dfrac{350}{500}$ or 70 per cent of rated current on the ammeter. Refer to the curve, Fig. 6, and at 70 per cent current with a load of 10 v.-amp. and a power factor of 80 per cent, the per cent ratio is found to be 99.96 per cent.

Therefore, the current is 350×99.96 per cent = 349.86 amp.

The ratio of the voltage transformer at the given load is 100.28 per cent. Therefore, the voltage is 6900×100.28 per cent = 6919.32 v.

The reading of the instruments corresponds to E′ I′, and E′ i′ cos b Fig. 8. Therefore, the power factor calculated from the readings is really $\cos c = \cos (a + b_1 - b)$

$$\cos (a + b_1 - b) = \frac{1650}{6900 \times 350} = 0.709{,}68$$

Therefore $a + b_1 - b_1 = 44^\circ\ 47'\ 32''$

Add from the curve, Fig. 5 (Jan. 1 issue), $b_1 = +10'$

Subtract from the curve, Fig. 6, $b = -7'$

$a = 44^\circ\ 50'\ 32''$

and $\cos a = 0.709{,}05$

Therefore, corrected power $= 1650 \times 100.28 \times 99.96 \times \dfrac{0.709{,}05}{0.709{,}68} = 1652.47$ kw.

Collecting the corrected values,

Volts = 6919.32
Amperes = 349.86
Kw. = 1652.47
Power Factor = 70.9 per cent

In the examples, a single phase load has been assumed for the sake of simplicity, and a single voltage and current transformer. A polyphase system generally uses two current transformers, two voltage transformers, single phase voltmeters and ammeters, and polyphase wattmeter. The method of correcting for the transformer errors, however, is exactly the same, allowing for the polyphase relationship. The instrument load on the instrument transformers is a single phase load on each, since even polyphase instruments provide separate circuits for the separate phases.

The volt-amperes required by various instruments and their power factor may be obtained from the manufacturer.

Grow, Stand Still or Go Backwards

By Chas. F. Knapp

GROW! And as you grow, sow, then likewise reap your harvest. Let your ambitions overthrow the tasks you deem the hardest. Hold fast where the friction comes, keep every inch you gain; a steady stride will take you there if "to grow" is your one aim!

Stand still!—but where are you at? The bottom—the top—in between? You can't get ahead by standing still. Or succeed by living a dream When you're standing still, you're envious of him who climbs to the top; you'd like to climb too—but how-to-do? Here's how—"Ambition."

Is isn't the speed that you're taking, nor it isn't the length of the stride; it's the step and in what direction, be your path narrow or wide. He who loses ambition, eventually ceases to grow, stand still—but, sooner or later, goes backward, to the bottom where all failures go!

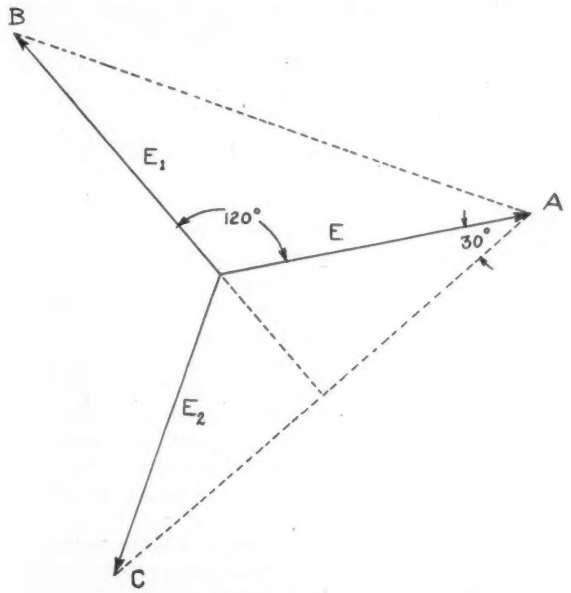
Calculation of Power in Three-Phase Circuits

EXPLAINING METHOD OF OBTAINING FORMULA USED IN CALCULATING POLYPHASE CIRCUITS. BY H. G. ROBERTS

FOR THOSE who are not familiar with how the formula, $P = 1.732\ EI \times$ power factor, for the calculation of power in a three-phase circuit is obtained, the following explanation may not be amiss:

In a three-phase star connection, as shown in the figure, where E, E_1 and E_2 represent the voltage in each phase the voltage across any two terminals of the machine is the vectorial sum of any two of the phase voltages, as represented in the figure by AC, and the line current equals the phase current.

This connection gives a phase difference of 30 deg. between the line and phase voltages, as noted in the



VOLTAGE RELATIONS IN A 3-PHASE STAR CONNECTED CIRCUIT

figure. Since the line voltage AC is the vector sum of the phase voltages E and E_2, $\frac{1}{2}AC = E \cos 30$ deg., and $AC = 2\ E \cos 30$ deg. In a table of trigonometric functions we find cos 30 deg. to be .866; therefore,

$$AC = 2 \times .866\ E = 1.732\ E$$

or, line voltage $= 1.732 \times$ phase voltage.

Another way of doing this is as follows:

Referring to the same figure, AB represents the voltage across the two phases E and E_1 and may be obtained by the formula:

$$\overline{AB^2} = E^2 + E_1{}^2 - 2\ E\ E_1 \cos 120 \text{ deg.}$$

But as $E = E_1$

Then $\overline{AB^2} = 2\ E^2 - 2\ E^2 \cos 120$ deg.

$= 2\ E^2 - 2\ E^2$ (sin 30 deg.)

$= 3\ E^2$

Therefore $AB = \sqrt{3\ E^2}$

$= E\sqrt{3} = 1.732\ E$

This gives the factor $\sqrt{3}$, which is often used in the three-phase power formula, and is equal to 1.732.

In a delta-connected armature winding the voltage across the terminals equals the voltage per phase, but the current in the line equals the current per phase times the $\sqrt{3}$, or 1.732; so the formula for the calculation of power is the same for either connection.

Having found how the factor $\sqrt{3}$, or 1.732, is obtained, we are now ready to proceed with the complete formula.

The power of a balanced polyphase system is the product of the power in each phase times the number of phases, whatever their interconnection may be.

In what follows

E = line voltage;
e = phase voltage;
I = line current;
i = phase current;
P = total power;
p = power per phase.

In a balanced three-phase star-connected circuit, the line current I is the same as the phase current i, and the line voltage E is 1.732 times the phase voltage e. The power in each phase is $p = ei \cos x$, where x = the angle of phase difference between the voltage and the current.

If we substitute for e its equivalent $E \div 1.732$, as $E = 1.732 \times e$ as above noted, and for i its equivalent I, as they are equal in this connection, the power per phase will be $\frac{E\ I \cos x}{1.732}$.

A similar line of reasoning applies to the delta-connected circuit. In this case, the line voltage E equals the phase voltage e, and the line current I is 1.732 times the phase current i. The power in each phase is $ei \cos x = \frac{E\ I \cos x}{1.732}$, the same as for the star-connected circuit. In both cases the total power P is the product of the power in each phase times the number of phases, or

$$P = \frac{3\ E\ I \cos x}{1.732} = 1.732\ E\ I \cos x$$

The factor cos x is the cosine of the angle of phase difference between the voltage and current, commonly called the power factor of the system. In any system having other than unity power factor, it is necessary to multiply the volt-amperes by this factor to obtain the true power.

Efficiency of Direct Current Motors

THE EFFICIENCY of direct current motors of various horsepowers, under full, three-fourths and half loads, is as follows:

		Load		
Hp.	R.p.m.	Full	Three-quarters	Half
5	1700	85.2%	83.5%	75 %
10	1700	87.3%	86.5%	80.5%
20	1150	88.5%	86.5%	82.5%
30	1150	89 %	87.7%	83 %
50	1175	88.6%	88.3%	86.5%

Thus the efficiency of all, at all loads, increases both with the size and with the load.

ROBERT GRIMSHAW.

YOU HAVE no idea how big the other fellow's troubles are.—Forbes Magazine.

Research in the Design of Explosion Proof Motors

DURING THE past 10 yr. the Bureau of Mines has had a broad experience in the testing and inspection of electric motors for coal-cutting machines, coal drills, storage-battery locomotives and other equipment which is used in mines where explosive mixtures of methane and air may be encountered. From this experience, the Bureau's engineers have reached the conclusion that the most satisfactory method of protecting a motor so as to prevent any sparks resulting from rough commutator, loose contacts or short circuits in it, from igniting the surrounding atmosphere, is to totally inclose the motor with a substantial casing having flanged joints. These joints should be metal-to-metal contact so that the shortest path from the interior to the exterior of the casing is not less than one inch in length.

On account of this experience with mining machinery, the Bureau has been asked whether an equal or less degree of protection would be sufficient for motors for service in or about places such as refineries, gasoline filling stations, cleaning establishments and pumping stations, or in any place where there is likelihood of explosive mixtures of gasoline or naphtha vapors and air accumulating.

As the Bureau's investigations did not cover the action of gasoline-air mixtures as related to the design of explosion-proof motors, it was decided to obtain data by conducting an investigation with these mixtures. Accordingly, a series of tests was made during the past eight months by E. J. Gleim and H. B. Brunot, associate and junior electrical engineers, respectively, of the bureau, in an endeavor to determine some measure of the protection required by a motor to be used in such locations, as compared with that required by a motor to be used in a coal mine, and to note the difference in phenomena when the two mixtures were ignited.

From the consideration of test data obtained in this investigation, and as reported in a technical paper recently issued by the Bureau of Mines, the following conclusions are drawn:

1. A motor which is to be used in a place where explosive mixtures of highly volatile gasoline vapors and air may accumulate, should have twice the protection against communicating an explosion within it to the outside atmosphere that it would require in order to be used safely in explosive atmospheres of methane and air. For less volatile gasolines the degree of protection required might perhaps be somewhat less.

2. On account of the greater pressures resulting from explosions of the gasoline-air mixture than from methane-air mixtures, the casing of a motor for use in the former mixtures would need to be mechanically stronger by about 45 per cent to withstand the internal explosion pressures.

3. In protecting a motor for use where there may be explosive gasoline-air mixtures, there may also be condensed vapors on the surfaces near the motor or even in the motor and constituting a fire hazard (should there be an explosion) which should be taken into consideration. In other words, when a methane-air mixture explodes there is no "residual" or condensation to give flame other than that of the burning gas, unless some different combustible such as coal dust is present, while in the gasoline-air explosion, any condensed gasoline vapors or liquid gasoline close at hand would be quite sure to catch fire and so add to the damage caused by the explosion.

If the gauzes are used as a means of protecting the motor it is to be expected that condensation and the less volatile matter adhering to them would serve to hold dust and dirt in the meshes and thus weaken and possibly destroy the effectiveness of the gauzes.

4. The lower ignition temperatures, the higher rate of propagation, and the higher calorific value of gasoline, together with the fact that the explosive limits are much lower than those of methane-air mixtures, point at once to greater difficulties in designing a motor for use in gasoline-air mixtures than for methane-air mixtures.

Based upon the Bureau's past experience and a consideration of the results of this investigation it is believed that the most suitable design would be a totally inclosed type of motor having flanges at least one inch in breadth and a casing sufficiently strong to withstand any internal explosions of gasoline-air mixtures, without rupture or discharge of flame.

Testing of Transformer Oils

By J. H. Blakey

WHEN used for transformers quality of oil is an important factor in obtaining good insulation in these appliances; in service the oil may be altered under the influence of the heat, the air (on account of its oxygen), and of the copper, which tends to produce catalytic action. These alterations and the deposits formed may be detrimental to the functioning of the transformer; for this reason, in some countries regulations have been drawn up for the furnishing of these oils, stipulating the tests to which they must be submitted. La Revue Brown-Boverie Cie. for August gives an account of these tests.

In France, the regulations require a test relative to the formation of deposits in the oil when maintained during 50 and 135 hr. at a temperature of 300 deg. F., then a discoloration test in amylic alcohol. These tests do not give any information as to the action of the copper, and are therefore insufficient. In England, the "sludge" test is used. This method, which consists of drawing air through a quantity of heated oil in contact with a band of copper, appears to be equally open to criticism. The German method, which is a determination of the "tar index" (Teerzahl) consists of introducing oxygen into the oil and of analyzing the acid products thus obtained.

Methods in each case are described in detail in the article cited. Finally, the Societe Brown-Boveri has its own test, which consists of heating the oil to a temperature of 230 deg. F. in a special copper receptacle, which is also described in the article mentioned. This method takes account also of the effects of the oil upon the cotton used as an insulator in transformers, and which gives rise to very complicated reactions. A color chart shows the appearance of two specimens of oil, one a good oil and the other of poor quality, after being kept for 100, 200 and 300 hr. respectively at a temperature of 230 deg. F. The oil, at first a clear yellow, becomes red, and if good forms no appreciable deposit.

Work on New Brooklyn Station Progressing

HUDSON AVENUE STATION OF BROOKLYN EDISON CO. NOW UNDER CONSTRUCTION WILL REPRESENT LATEST PRACTICE IN DESIGN OF CENTRAL STATIONS

CONSTRUCTION of the new Hudson Avenue station of the Brooklyn Edison Company, Inc., was begun last August, and the foundation contract, which was awarded to the Frederick Snare Corporation, is well under way, the building foundations nearly ready for steel and the condensing tunnels about one-half complete. The ultimate capacity of the station will be 400,000 kw., provision for one-half of which will be made in the first section of the building, now being erected adjoining the Brooklyn Navy Yard. Eventually, an extension of equal size will bring the completed station to Hudson Avenue on the west. On the north, the property faces the East River, on the south it extends to John St. Marshall St., which intervenes between John St. and the East River and ends at the Navy Yard, will be bridged by the station, the electrical galleries being located to the south of Marshall St., while the turbine room, boiler house, and coal towers will lie parallel to this street on the north, in the order indicated.

As in the case of other central stations in the metropolitan district, supply of coal and circulating water fixed the necessity of having the site adjoin the water front. This in turn was partly responsible for the adoption of a voltage of 27,600 for the distributing mains. Local congestion under the street surface was also a factor in the decision to distribute at high voltage.

An idea of the magnitude of the work on foundations may be gained from the following approximate figures on quantities. About 15,600 foundation piles of long leaf yellow pine, 12-in. butts, averaging 30 ft. in length, spaced at 30-in. and 36-in. centers according to location, were driven beneath the concrete of turbine room and boiler house foundations. Excavation, exclusive of dredging but including the work under the switch house, amounts to 119,000 cu. yd., and 50,000 cu. yd. in addition have been removed by dredging. The concrete employed in the foundations will reach a total of over 50,000 cu. yd. The typical thickness of concrete is 7 ft., with 10 ft. thickness under the operating room and 6 ft. under the switch house where piles are not required.

Boiler and turbine room equipment to be included in the original installation provide for one-fourth the ultimate capacity as planned, and constitute the first of four similar units which it is proposed to install. Two main generators rated at 62,500 kv.a. generate current at 13,800 v. and 60 cycles, and are directly connected to auto-transformers giving a voltage of 27,600 for the distributing system. The two main turbines are to be of 50,000 kw. rated capacity each, and to be single shaft machines. One is to be a General Electric Curtis type, the other a Westinghouse-Parsons tandem compound. The General Electric turbine will be connected by rubber expansion joint to a Westinghouse condenser having 70,000 sq. ft. of cooling surface. The method of suspension of the condensers will not be the same, that under the General Electric turbine being supported by springs from the foundation, with rubber expansion joint, while that under the Westinghouse turbine is hung from girders below the turbine.

Eight Babcock & Wilcox boilers, each having a heating surface of 19,650 sq. ft., are to be installed with the first station unit. Steam will be supplied at 265 lb. gage pressure and 200 deg. F. superheat at the throttle. Of the eight boilers for each group of two main units, seven will be required for operation, while the eighth may be held out as a reserve or for maintenance work. The original stoker equipment will include six Westinghouse and two New Frederick stokers, the latter supplied by the Combustion Engineering Corporation.

In the removal of ashes from below the furnaces by hydraulic methods, a novel feature will be introduced.

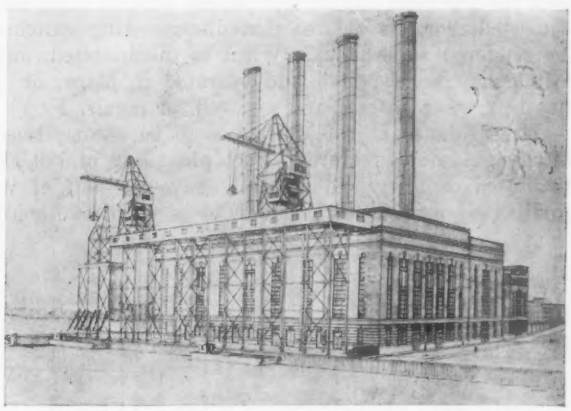


FIG. 1. ULTIMATE HUDSON AVE. STATION WILL BE 400,000 KW.

The ashes will be run through sluices to a large storage pit under water, from which they will be excavated by a locomotive crane and clam shell bucket and dumped on ash scows.

Three boiler feed pumps are to be installed for each group, two of which are necessary for operation and one spare. Of these, two will be electric and one steam driven. All other auxiliaries will be motor driven. All driving motors will be of alternating current type unless variable speed is required as in the case of blower and stoker engines, hoists, and cranes. Direct current will be obtained through motor-generator sets, the motors being supplied from a 2300-v. bus.

Each main condenser will be served by two circulating pumps, either of which can supply 50,000 gal. of cooling water per min. The intake and discharge tunnels are designed for an ultimate capacity of 800,000 gal. per min. As an offset to this enormous figure may be mentioned the ultimate capacity for which the city water mains are designed, namely, 12,000,000 gal. per day. The intake tunnel originates at the Hudson Avenue end of the water front, and shortly beyond the intake screens is divided into two tunnels which run parallel to each other under the west and south sides of the operating room. The typical section of each is 20 ft. 8 in. high by 11 ft. wide. The discharge tunnel runs parallel to the intake tunnels and on the same level with

them under the north side of the operating room, and thence to the northeast corner of the property, as far as possible from the intake. This tunnel is 24 ft. high by 15 ft. wide in typical cross-section.

Aside from the electrical features already mentioned, construction and operation on the electrical end are to be simplified in several interesting ways. The vertical isolated phase arrangement for busses and circuit breakers will be employed, with the A, B, and C phase switches and busses on different floors, with an operating floor above, and the potential transformers and grounding and testing switches on a lower level. Special oil circuit breakers are provided, each supplied with current transformers, thereby saving the space necessary for current transformer compartments. Each circuit breaker with its connections forms a cubicle, which is so suspended from above as to obviate the necessity for bus, disconnecting switch, and circuit-breaker compartments, eliminating a great deal of brickwork. Operating from the top floor, any switch may be lowered until disconnected from its bus, so that disconnecting switches are rendered superfluous. When so disconnected, any switch may be inspected and operated in place; or it may be further lowered and removed for repair.

Heat balance at this station is to be accomplished with several novel features. Each plant unit of 100,000 kw. rated capacity will normally have one-half of its auxiliaries supplied with power by a 4500 kw. house alternator and the other half by transformers from the main bus. The turbine driving the house alternator will exhaust to a surface condenser through which the hotwell water from the two main units will pass on its way to the suction of the boiler feed pumps. The feed line beyond the house alternator condenser will also receive the condensate from this condenser and from the closed heaters, and the discharge from the eductor condenser for the high pressure gland seal of the General Electric turbine. The connection from surge tank will also come in at this point. The line will then divide, and the feed water will pass through the feed pumps and through two pairs of high pressure and low pressure heaters which use steam bled from different points of the main turbines, and thence to the boilers.

Besides the two sources of power for the auxiliaries mentioned in the last paragraph, such power may be derived in case of need from a frequency changer working on 25-cycle current from the Gold St. Station.

FIG. 3. SITE OF HUDSON AVE. STATION FACES EAST RIVER AND IS LOCATED NEAR BROOKLYN NAVY YARD

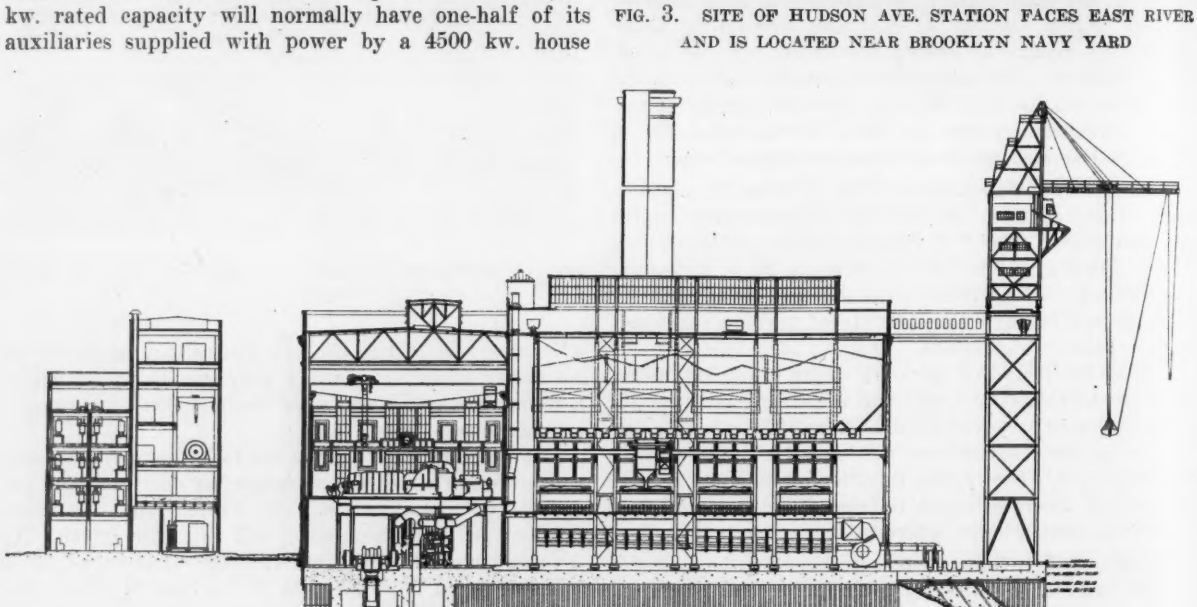


FIG. 2. TWO 50,000-KW. UNITS WILL MAKE UP FIRST SECTION OF THE PLANT

Water rates for the Westinghouse and General Electric turbines will be 10.44 and 10.45 lb. per kw.-hr. respectively when running at full load. The most economical loads are given at 36,000 kw. for the Westinghouse machine, with a water rate of 10.10 lb. per kw.-hr., and 40,000 kw. for the General Electric machine, with a water rate of 10.05 lb. per kw.-hr.

Illustrations shown give a general view of the station, a cross-section, and a recent view of the progress of work. The station, as noted in a previous issue, is being designed by the engineers of the Brooklyn Edison Co., with Thomas E. Murray, Inc., as consulting engineers.

Air Agitating Systems for Raw Water Ice

Low Pressure System Requires Less Power and High Pressure Method Reduces Labor Cost. By H. R. Halterman*

SYSTEMS of air agitating for raw water ice plants may be divided into two general classes and an intermediate system which has certain features in common with the two general types. The low pressure system, where the air is used at a pressure of from 3 to 5 lb., was the first of the two general systems to be used, while the high pressure system in which the air is compressed to 25 or 30 lb. pressure and the moisture reduced by cooling the air with normal brine temperature was later adopted. Although the intermediate system is truly a high pressure system, it embodies the drop pipe feature in which the drop pipe is frozen into the cake and removed as the ice is harvested. This system has only recently become popular.

Equipment for the low pressure drop pipe system is composed of a power-driven rotary blower, connected directly to air mains leading to tanks where the cans of water are to be agitated. From these mains there are a series of pipes usually ½ or ¾ in. in diameter leading across the tank for each row of cans. These laterals are tapped for air outlets at each end and are connected by a short piece of flexible hose to the drop pipe which is supported by a bracket at the center of the top of the can. This drop pipe extends into the can of water to a depth within 8 or 10 in. of the bottom of the can, at which point the air is released and rises to the surface, agitating the water in the can during the process of freezing. A restricting orifice is placed in the air line, usually at the hose connection to the drop pipe, and a pressure carried to give a quantity of air through this orifice sufficient to produce proper agitation of the water.

Comparison of Air Required

Low pressure systems of this type are sometimes preferable because of low first cost and may be found satisfactory where water contains few impurities or where a high quality ice is less important. Such a system also has a lower power cost per unit volume of air, since it is possible to compress 100 cu. ft. of free air to 3 lb. pressure with 2½ hp. by means of a rotary blower and it requires about 10 hp. to compress 100 cu. ft. of free air to 30 lb. pressure with the use of an air compressor.

It must not be inferred from the foregoing statement that it costs four times as much for power per can of ice with the high pressure system as it costs with the low pressure system, for in the high pressure system only about 0.2 cu. ft. free air per can is used, while the low pressure system requires about 0.5 cu. ft. of free air per can for a good quality ice. Actual power cost in the low pressure system is from our experience about ¾ as much as in the high pressure system.

Flexibility is another feature of the low pressure system; for, should there be an interruption of air service for a short period of time, it is hardly noticeable on the quality of the ice and the agitation is resumed when the air service is restored.

This low pressure system, while more simple to install and operate, has its objectionable features. In removing the drop pipes before they are frozen in the center of the cake, the agitation is stopped and in freezing the water that remains in the center of the cake without agitation, a white core is formed, producing an inferior grade of ice. The extra labor of handling these air pipes is a considerable item and in keeping the air in the drop pipe from freezing up in cold weather is by no means of little consideration.

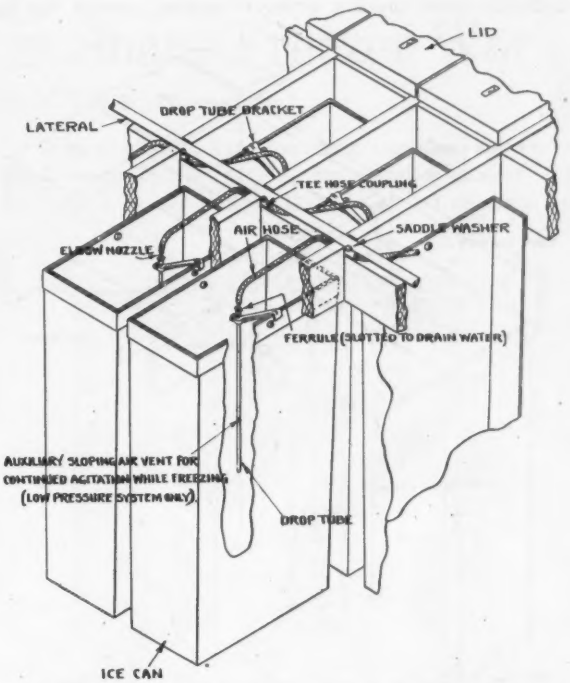


FIG. 1. SYSTEM FOR LOW AND MEDIUM PRESSURE AGITATION. WHEN USED FOR MEDIUM PRESSURE, THE DROP TUBES ARE FROZEN IN CAKE

Another system of the low pressure type which has characteristics different from the one just described is one in which stationary cans are built in as part of the freezing tank to which a permanent air connection is made at the bottom of the can through the bottom of the tank. The water in the can is kept in agitation until the center of the cake closes, giving a quality of ice comparing favorably with that of the high pressure air agitating systems. In this system, the elimination of handling the drop pipe is much in its favor. The first cost of this system is high because of the necessary duplication of freezing tanks due to the method of harvesting ice from the built-in stationary cans.

Air Connection Easier in High Pressure Method

Development of the high pressure system was brought about in an attempt to correct the objectionable

* General superintendent of ice factories, Consumers Co., Chicago, Ill. This discussion was presented at the convention of the National Association of Practical Refrigerating Engineers at St. Louis on Nov. 4.

features of the low pressure system. To eliminate the labor of removing drop pipes, a permanent air tube was built into the can. Since this air tube is exposed to the cold temperature of the brine, any moisture present in the air may freeze in the tube, stopping the flow of the air to the can. Thus, to use this tube successfully, it was necessary to remove the moisture from the air. This phase of air conditioning was brought about by increasing the pressure and decreasing the temperature of the air. The equipment for this system is composed of a power driven air pump, a dehumidifying system and a pressure reducing valve.

These air headers and laterals are not essentially different from the low pressure system, except for the

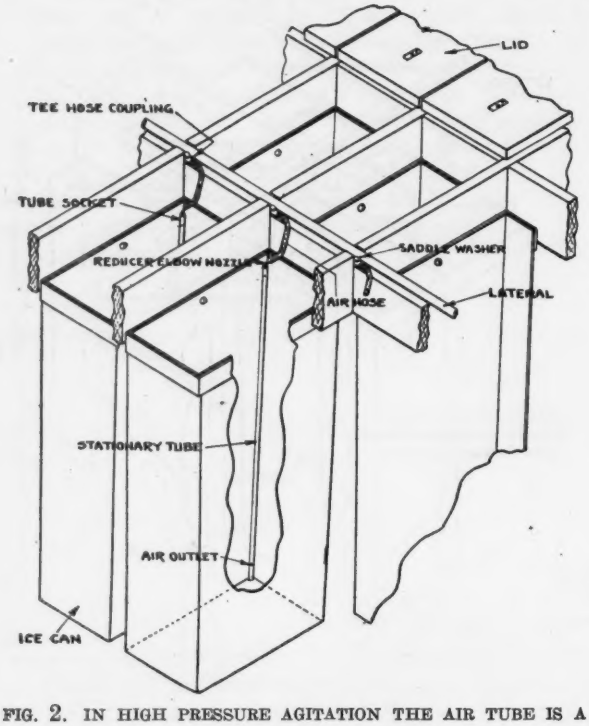


FIG. 2. IN HIGH PRESSURE AGITATION THE AIR TUBE IS A PART OF THE CAKE

immediate air connection to the can which must necessarily be a simple, quick connecting, durable connection. This is usually a tapered nipple fitted accurately into the air tube of the can. In this nipple is placed the restricting orifice which being quite small is often drilled larger than necessary and reduced by inserting a copper wire which serves the dual purpose of restricting the orifice and making it possible to clear the orifice quickly in case it is stopped by a particle of scale, frost, or other foreign substance carried over by the air. It has been determined by practice that an orifice of proper size to supply sufficient air for agitation with 18 lb. air pressure is that made by a No. 53 drill using a No. 16 B. & S. gage wire for restricting. This gives an orifice equivalent to that of a No. 75 drill.

In this high pressure system, the compressor delivers air at 25 to 30 lb. pressure from which part of the oil and some moisture is taken by means of a separator. This pressure of 30 lb. is not arbitrarily chosen, but is the pressure at which air can be practically dehydrated at the available brine temperature of 14 or 16 deg. F.

Air contains an amount of moisture that depends on its temperature and pressure. The higher the temperature, the more moisture it can absorb. The higher the pressure, the less moisture it can contain; however, when air is compressed, its moisture content, due to the rise in temperature, does not offset the effect of the higher pressure and some of its moisture is dropped due to this pressure. This process of moisture elimination is carried further by cooling the air at the higher pressure by some artificial means.

Removal of moisture from the air, though a simple process, requires some attention. The first step of removing the superheat is done by forcing the warm air through double-pipe coolers through which cold water is passed, and the air temperature brought to within a few degrees of the cooling water temperature, where approximately 50 per cent of the work of removing the moisture is done and this moisture is drawn off by means of a trap. From the double-pipe coolers, the partly dry air passes to the brine cooled dehumidifiers, which are made up of two steel tanks equipped with separate brine coils. The remaining moisture in the air is still further reduced by passing the air around the coil through which cold brine is pumped. These tanks are connected in series by means of a four-way reversible cock and a bypass for reversing the flow of the air over the cooling coils.

As the frozen moisture from the air is deposited on these coils, they become heavily coated with frost. To defrost the coils, the cold brine is shut off from one coil and the air from the double-pipe cooler passes over the heavily frosted coil where it gives up some of its remaining heat, melting the frost from the coil. The air being cooled, it passes to the second tank where the cold brine in the second tank coil completes the drying process. By this method of reversing the air and changing the brine coils in the tanks alternately, one bank of coils is kept free from frost and the operation of freezing the air dry is continuous.

After the drying process is complete, the air passes through a reducing valve where the pressure is reduced from 30 to 18 lb. It has been determined that the latter pressure is necessary to keep the water circulating until the cake is entirely frozen. It is during the early part of the ice formation that the restricting orifice plays its important part by supplying a limited quantity of air to the open or unfrozen cans. Without the restricting orifice, the air would have only the resistance of the head of water in the can and would permit an excessive supply to the open can. This orifice maintains the 18 lb. pressure in the lateral, and as the cake closes and offers a resistance greater than that of the orifice, the 18 lb. pressure becomes effective beyond the orifice and acts to keep the opening through the ice clear and maintain circulation of the water until completely frozen.

As previously stated, the intermediate system embodies characteristics of both the original low and high pressure system, using the drop pipe of the low pressure system freezing the air tubes into the cake and removing them by the thaw needle process at the dump as the ice is harvested. To keep the tubes from clogging with frozen moisture, an air drying system must also be used and to remove the moisture successfully from the air at

available brine temperature, a pressure higher than that produced by a rotary blower is necessary, so in this system an air compressor must be used. Under favorable atmospheric conditions, this system will, however, work under an initial pressure much lower than that required for the high pressure system, as the air, during agitation, does not come in contact with temperatures below freezing until the cake is completely frozen.

Air drying apparatus for this intermediate system is composed of a closed vertical tank with a brine coil, this coil being partly submerged in water or brine. The air enters the tank at the bottom, passing up through the water where it is cooled, and as it passes over the exposed surface of the coil, the drying process is completed to a degree satisfactory for agitation in this drop pipe system.

This intermediate system gives a quality of ice which compares favorably with the high pressure system, although there is the extra work of handling drop pipes. This system has been made popular in the smaller plant through the gang harvesting method, where the tankman has ample time to care for thawing and handling drop pipe. Such a system has an intermediate first cost, gives a favorable quality of ice, but probably has a higher operating cost than the other systems.

Difficulties Encountered in Sharp Freezer Work

TENDENCY OF THE COLDEST COILS TO FLOOD IS EXPLAINED

IN A CERTAIN refrigerating plant there are four sharp-freezers for freezing fish. Each freezer contains two sets of coils, one on either side of the room, with a passageway down the center. The coils are built up in the form of shelves, sheet iron covers are placed on these pipe shelves, and the fish, halibut and salmon, are laid directly on the sheet iron plates.

These coil shelves are made up of 1½-in. pipe and are 24 ft. in length, 14 shelves in height, 10 in. between shelves, and 11 pipes in width.

Is it possible to have too many shelves? That is, too many shelves in height, or too much length of pipe, from where the ammonia liquid enters at the bottom of the coil, to where the vapor leaves at the top? All coils in each stack are fed from a header at the bottom, and the vapor leaves through another header at the top. The main liquor line approaches the four freezers at about the center, where a tee divides the line, each side of the tee feeding two freezers.

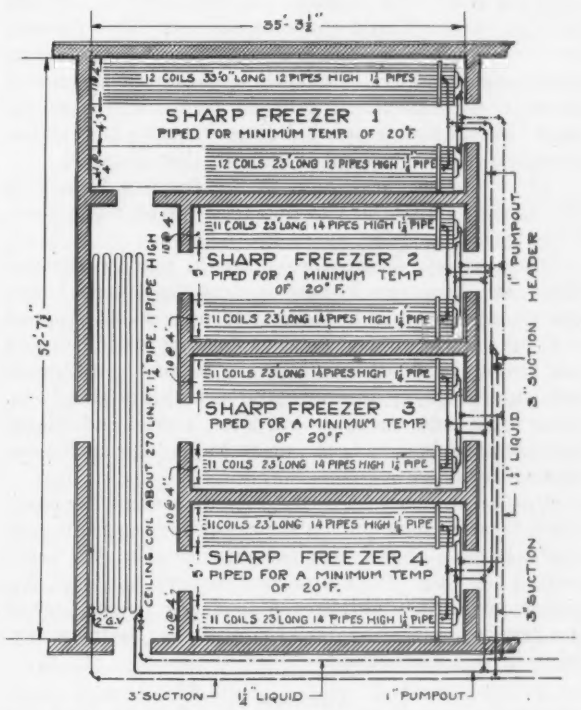
I have noticed that when all the expansion valves are set about the same, the liquor has a tendency to run to the end freezers. I have also noticed the liquor has a tendency to run to, and flood the coldest freezers.

I find that when the expansion valves are set so that the coils are boiling vigorously all the way, from bottom to top, the temperature in the room drops very slowly. On the other hand, when all the coils except the top one or two shelves, are boiling, the temperature drops faster. In other words, when the coils are flooded, they seem to stop working. The difficulty, I find, is to tell when the coils are flooded because when in this condition they seem to quiet down, make less noise at the top, just as they do when not enough ammonia is being fed to the coils.

The different coils do not sound the same when they are boiling. Some coils can scarcely be heard to boil near the top where they are working at their best; other coils make considerable noise near the top when working properly.

Is there any way of telling, by sound or some other simple test, when each coil has the right amount of ammonia in it, when working at its maximum? I understand, of course, that if we had thermometers at the outlet of each coil, we could, by comparing temperature of vapor with the back pressure, tell when the vapor leaving the coils was near the dry saturated condition, but there are no thermometers except near the compressors.

Is it possible to have too much machine capacity on the freezers; that is, carry too low a back pressure? One operator here claims that the back pressure should be held at about zero gage, right at the beginning, while another thinks freezers should be started off at a higher pressure, letting the back pressure drop, as the temperature in the freezers falls.


35'-3½"
12 COILS 35'0" LONG 12 PIPES HIGH 1¼ PIPES
SHARP FREEZER 1
PIPED FOR MINIMUM TEMP OF 20°F.
12 COILS 23' LONG 12 PIPES HIGH 1¼ PIPE
11 COILS 23' LONG 14 PIPES HIGH 1¼ PIPE
SHARP FREEZER 2
PIPED FOR A MINIMUM TEMP OF 20° F.
11 COILS 23' LONG 14 PIPES HIGH 1¼ PIPE
11 COILS 23' LONG 14 PIPES HIGH 1¼ PIPE
SHARP FREEZER 3
PIPED FOR A MINIMUM TEMP OF 20°F
11 COILS 23' LONG 14 PIPES HIGH 1¼ PIPE
11 COILS 23' LONG 14 PIPES HIGH 1¼ PIPE
SHARP FREEZER 4
PIPED FOR A MINIMUM TEMP OF 20°F.
11 COILS 23' LONG 14 PIPES HIGH 1¼ PIPE
52'-7½"
CEILING COIL ABOUT 270 LIN. FT. 1½ PIPE, 1 PIPE HIGH
2 G.V.
1" PUMPOUT
3" SUCTION HEADER
1¼" LIQUID
3" SUCTION
3" SUCTION
1¼" LIQUID
1" PUMPOUT

PLAN SHOWING THE DISPOSITION OF THE SEVERAL BANKS OF SHARP FREEZER COILS

Temperature in the freezers, after they are filled and closed up, is usually about 18 deg. or so above zero, and we are expected to have them down to 20 deg. below zero in about 18 hr.

Our practice here has been to set the expansion valves strong at the start so as to get the coils filled up with ammonia, and then pinch down on the expansion valves. The result is that the temperature drops 6 to 8 deg. the first two hours, and after that very slowly. The initial

big drop in temperature is due, of course, to the high temperature of the rooms right after the men get through putting in the fish.

I have always been under the impression that the more ammonia you could get in the evaporating coils, without having it slop over in the suction line, the more work you would get out of the coil. But this idea doesn't seem to work out with the sharp-freezers, and I am wondering whether the height or number of shelves, length of pipe in each coil, have anything to do with it.

It has been proposed to divide the coils in the center, from bottom to top, making two coils, where there is but one now; each coil would then be 7 pipes high instead of 14, as at present. Do you think that would help matters any?

At present the foreman of the fish freezing plant complains that fish on the top shelves are not always frozen as are those on the lower shelves.

I am told that other fish freezing plants near here have a less number of shelves, less height in their sharp-freezers than at the plant here, and that they get quicker results than we do.

What would the probable pressure drop be between the sharp-freezers and the compressors? The freezers are in a separate building, about 400 ft. distant from compressor building. The suction line drops down and passes underneath some railroad tracks and then up again into the compressor building. Operator here claims there is a drop of several pounds in that distance.

After the fish have been in the freezers from 8 to 10 hr. the temperature begins to drop at much more rapid rate, 5 to 6 deg. every two hours.

There is one thing more I should like to mention. When, say, two freezers have been on for several hours, and the temperature in these two freezers has dropped to about zero, and then two more freezers just filled with fish, are put on, the temperature in the first two freezers will suddenly stop dropping and practically stand stationary for two or more hr., even though additional machine capacity has been put on to hold the back pressure uniform.

One of the men here contends that when the additional freezers were put on the vapor leaving these coils would be at a slightly higher pressure than the vapor leaving the coils of the first two freezers, and that this higher pressure would have a tendency to back up in the first two and temporarily stop them. Is there anything in this contention? E. E.

Answers

In the course of operation, it appears that when all of the expansion valves are set as nearly the same as possible, the liquid has a tendency to flow more strongly to the end freezers. This is a condition which is not infrequently met, especially when the line leading to the end freezers is taken from the end of the header and the feed to the intermediate freezers is tapped off at the side. The phenomenon can usually be accounted for on the basis of pipe friction and inertia of the liquid which makes it tend to travel straight ahead instead of to one side through the T outlets provided for the intermediate feeds.

Tendency toward "flooding" the coils in the coldest freezer is a condition which arises due to the pressure—temperature relations, of the refrigerant. The action may be explained as follows:

Pressure of any vapor of any medium, whether a refrigerant or not, increases with temperature. If two steam boilers, for example, are connected in parallel as regards both steam outlet and feed water inlet, and the fire was "pushed" more under one than the other, it would be found, as in the case of the freezer coils, that the "colder" one would "flood." The reason for this is two fold, first, because all piping systems impose some friction, which tends to retard the flow of the passing medium by imposing so-called back pressure. This "back pressure," due to friction, increases with the flow of the medium. Even though the two boilers in question are connected in exactly the same way to the header, there will be a slightly greater pressure in the one in which the evaporation is most rapid and if, as is assumed, the boiler feed lines are also connected in exactly the same manner and in parallel the feed water will flow most readily to the boiler having the lower, though possibly only very slightly lower, pressure.

In the fish freezers, the several coils under consideration are nothing more or less than low temperature boilers connected in parallel as regards both liquid feed and gas return. The fact that the working medium employed in these boilers is ammonia or some other refrigerant, instead of water, is of little moment. It is further obvious that if an unfired boiler or a correspondingly lower temperature coil were connected to the respective systems, they might even act as condensers, for, being at lower temperatures than the respective media, they would be in position to absorb the latent heat from the vapors causing them to return to the liquid state.

It seems that the temperature of the freezers drops less rapidly when the ammonia in the coils is boiling vigorously from bottom to top than when all the pipes except the top one are active. It is believed that there must be some other element than quantity of liquid entering into the problem. It may be possible, for example, that the back pressure under the two conditions described, is not the same. There is, unfortunately, no way of telling just what is going on inside of a set of expansion coils, close study of the peculiarities of the plant under purposely varied conditions studied one at a time with the other conditions maintained as nearly unchanged as possible should shed more light on the situation than can be given by an outsider. Even thermometers inserted in the gas return lines of freezers are of comparatively little value because of the comparatively small temperature differences obtaining between the refrigerant and air usually employed in sharp freezer work.

Dividing the coils which now contain 336 lineal feet each, might give some benefits in that it would halve the liquid head in the coils, which are now about 11 ft. high. This liquid head, of course, has the same effect as back pressure. In other words, an increase in pressure of two pounds, for example, might prevent boiling (and consequently refrigeration) when the temperature difference, outside and inside the pipes is slight. In practice this would mean the necessity of maintaining 2 lb. lower back pressure at the machine in order to overcome it and a reduction in machine capacity approximately proportionate to the reduction in absolute back pressure would be the penalty.

Dividing the coils would entail the disadvantage of doubling the number of expansion valves to regulate and

since maximum service can not be maintained to the return end of the coil without danger of liquid returning to the machine, it is possible that complaints might arise regarding the freezing results on twice as many top shelves, under the proposed arrangement.

Temperatures drop much more rapidly after the fish have been in the freezers for 10 hr. This is due to the fact that the "latent heat of fusion" of the outer surfaces of the fish has been extracted and that of the interior of the fish is only more slowly available since it has to pass through the frozen exteriors.

When two freezers have been in for some time and their temperatures reduced to about zero, the addition of two freshly filled freezers prevents the further lowering of temperatures in the first two for two hours or more—even when additional machine capacity is provided to maintain the back pressure constant. The constant back pressure is probably observed at the machine. Were it possible to observe it at the outlet of the several freezers separately by means of mercury columns, it would probably be found, as suggested, that the warmer coolers were exerting a higher pressure than the colder ones to the disadvantage of the latter. With the addition of 100 per cent more freezers amounting to more than that per cent more work due to their being freshly stored, the friction head of 400 ft. of return piping to compressors would be materially increased and if the assumption above made, to the effect that the back pressure is observed only in the compressor building, is correct, this additional pressure will be imposed on the freezers, thereby causing their temporary suspension of work. Without detailed data regarding quantity of gas flowing, size of pipes, number and nature of fittings, etc., it would be impossible to calculate the drop in pressure due to friction head. It would be more satisfactory to install another gage at the freezers and make allowance for the difference in the operation of the machines.

Back pressure should always be carried as high as possible and at the same time produce the desired temperatures. This from the standpoint of economy on the one hand and machine capacity (if this is a consideration) on the other.

A pound of ammonia produces more refrigerating effect at a high back pressure than at a low, and a compressor passes more pounds per minute at the same speed at high, than at low back pressure.

The amount of compressor capacity that should be focused on the load, must be determined, not only from the standpoint of the above considerations, but also from that of effect on the product as well. It is believed that the quicker the freezing of fish the better the product on thawing. If this is true this last consideration might readily outweigh the others.

If water from the very bottom of a well is more desirable than that on the surface, it may warrant the extra work of going to that low point to obtain it, but if not, it is obviously poor economy of labor to raise it any more than is necessary. If the water in the well runs in near the top it is likewise folly to let it fall to the bottom in order that it may be drawn up from there. It should be caught as near the top as possible to save labor of hoisting. Carry the highest back pressure possible at all times consistent to the time allowed. Where some of the water must come from the bottom of the well and some may come from the top, employ both. Where a low temperature must be produced and a higher one may be used, employ two back pressures if possible.

F. E. MATTHEWS.

Chase Metal Works Heating System

COMMENTING ON the description of the heating system of the Chase Metal Works which appeared on page 139 of the Jan. 15 number of Power Plant Engineering, John E. Williams, chief engineer of the plant, has this to say in regard to the control of the system for various outdoor temperatures:

When the heating season sets in, the water from the river is cut off by closing the valve on the suction pipe. At the same time, the valve connecting the heating system with this condenser is opened, putting on 35 lb. static head.

This water is circulated through the condenser into the heating coils and returns with about 20 deg. drop. This difference, multiplied by the amount of water going through the condenser, calls for about the full load on the turbine, at about 10 deg. above zero. For this class of work, the condensate pump should have capacity enough to supply a jet-condenser.

When the turbine is fully loaded and the correct temperature is being maintained on the heating coils, the condensate pump handles the condensed steam only, maintaining a vacuum corresponding to the discharge temperature.

Higher out-of-door temperatures call for lower temperature in the coils. This can be done by switching some of the load on the other turbines; but most of the time this is not desirable, so cold water is turned into the suction pipe of the condensate pump regulating this water to maintain the right temperature on the coils.

At 60 deg. out-door temperature, the turbines run on practically normal vacuum. As the weather grows colder, a little of the cold water on the condensate pump is cut out, which gives a vacuum due to the temperature on the coils; inasmuch as the condenser heater is attached directly on the turbine, there is no discrepancy between temperature and vacuum.

It is generally conceded that heating can be done more economically with steam engines and the turbine has been looked upon as not quite as well adapted for heating. This objection is removed when the turbine is connected as shown in the illustration on account of the better vacuum obtainable. Other turbines working on this foregoing principle, heat water for manufacturing purposes.

This plant has been using these condensers for this work for over 10 yr. and notwithstanding the varying temperatures they give no trouble whatever. This could be done with pre-heaters for heating raw water for manufacturing purposes, but the surface condensers are just as successful at this work and pre-heaters that would call for brass tubes to handle the raw water are eliminated.

TO DETERMINE the exact amount of damage done by certain impurities in the electrolyte or plates of storage batteries the Bureau of Standards has recently undertaken a series of investigations along this line. The first of these, having to do with the effect of local action, has now been completed and the results published in Technical Paper No. 225.

Turbo Compressors Growing in Demand

FOR LARGE VOLUMES OF AIR AT LOW AND FAIRLY HIGH PRESSURES TURBO COMPRESSORS AND BLOWERS ARE MEETING WITH FAVOR

TEN or fifteen years of commercial operation of turbo blowers and turbo compressors in this country makes it unnecessary to enlarge upon their merits or to repeat the many arguments in their favor. The ever increasing number of installations of these machines, and their application to the most varied purposes, is proof of their rapidly growing popularity, as well as indisputable evidence of the success which they have given in practical operation.

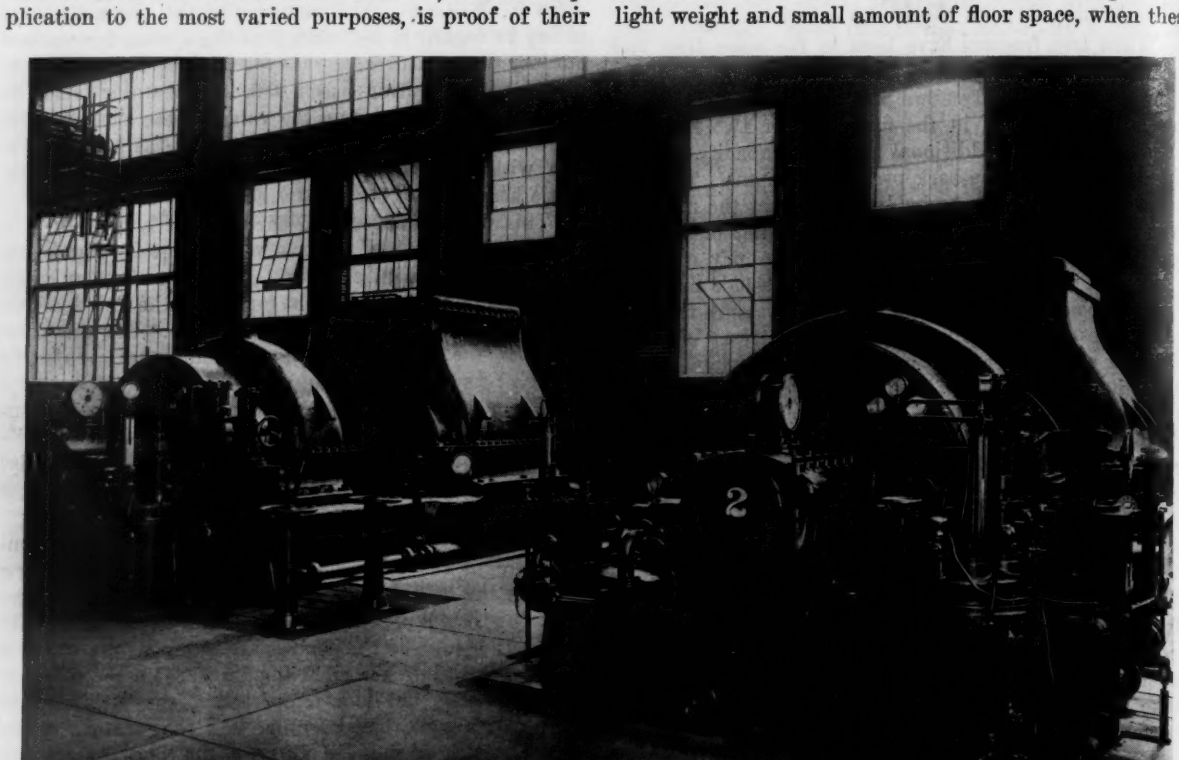


FIG. 1. TWO 40,000-CU. FT. PER MIN. TURBO BLOWERS SERVING IRON BLAST FURNACE AT ST. LOUIS COKE & CHEMICAL CO., GRANITE CITY, ILL., BASED ON 15 TO 25 LB. DISCHARGE PRESSURE

At the present time, the most important use of turbo blowers is for furnishing blast for iron blast furnaces. For such work, the turbo blower is steadily gaining a predominating position. This is evidenced by the fact that a large majority of the latest and largest new blast furnace plants are entirely equipped with this type of blowing apparatus.

Requirements for blast furnace service are extremely severe; it is necessary to maintain continuous operation under all circumstances, as the loss of the "wind" would lead to disastrous consequences at the furnace. Furthermore, the proper functioning requires that the supply of air be gaged accurately and be maintained uniformly. This must be assured in spite of any variations of resistance in the furnace, and, consequently, of the blast pressure, as well as any variations in the steam conditions, vacuum, etc., of the plant. All of these conditions are met successfully by the turbo blower.

Large capacity is an inherent qualification of the turbo blower. One blower is always sufficient to blow even the largest blast furnace and units up to 60,000 cu. ft. per min. capacity are in service. The outstanding features of the turbo blowers are their compactness, light weight and small amount of floor space, when these features are compared with a reciprocating engine. This necessarily means smaller cost of installation, easier handling of all parts, etc. As a class of machine, the turbo blower is one step in the general trend of modern machinery toward higher output per pound of weight by the use of higher speeds.

In the vast majority of installations, the turbo blower is direct-connected to a steam turbine. This is due to the extreme flexibility of the steam turbine with regard to power and speed. The steam turbine can accommodate itself almost instantaneously, and at the same time economically, to any conditions required for the blower. In all blast furnace installations the steam turbines operate condensing.

For blast furnace service a constant, uniform volume of air is required and consequently such blowers are furnished with constant volume regulation. For this purpose, a venturi meter is favored, as this supplies, at the same time, the means of accurately measuring the volume of air delivered by the blower. The throat of the venturi is connected to the balance float or bell of a

gasometer type regulator, variable suction pressure to the venturi throat causing this float to rise or fall. By suitable connections to the steam admission valve the steam flow to the turbine is regulated in such a way as to maintain constant suction pressure at the venturi throat and, therefore, constant air volume. Through the use of different counterweights or the variable compression of the spring, the regulator float can be set to hold any desired volume. As now built, turbo blowers are classified as single-stage and multi-stage blowers, according to the number of impellers used. A single-stage blower is limited in pressure to approximately 3 to 5 lb., this pressure limitation being in accordance with the

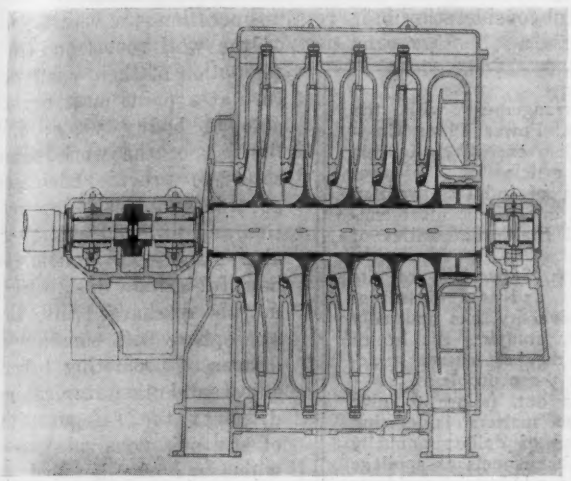


FIG. 2. FIVE-STAGE WHITAKER TYPE TURBO BLOWER DESIGNED FOR 50,000 CU. FT. CAPACITY AT 30 LB. PRESSURE

speed at which the blower operates. Above thi[s] ulti-staging, that is, placing of several impellers i[n] s, become necessary. In blast furnace work where i-mum pressure of from 25 to 30 lb. gage is requ[ired] he Ingersoll-Rand Co. uses four or five stages. A of such a multi-stage blower is shown in Fig. 2.

Among the more important details of construction which are incorporated are complete water-jacketing of the blower casing, rigid shafts, closed impellers of high-grade alloy steel, forced-feed lubricating throughout and Kingsbury thrust bearing for the steam and air shafts. Turbine and blower shafts are supported independently and connected by a flexible coupling. It is customary to mount the turbine and blower on a rigid, common bed plate, which serves also as an oil container, and carries the necessary accessories, such as oil cooler and strainers, auxiliary oil pump, regulator, etc.

For Bessemer converter service constant pressure is required, and the blowers have a constant pressure regulator, which maintains an even blast pressure irrespective of the output of the blower. For this service, the turbo blower has many advantages, chief among which is the fact that it can be started and stopped quickly. Where the blast is required for some 10 to 20 min. duration, and the machine and the blowing apparatus is not in actual service except during this period, this question of starting and stopping quickly is very important.

Besides the application to the heavy iron and steel industries, numerous other uses of the turbo blower could be mentioned. They are equally satisfactory for low pressure work, such as the blowing of cupolas or steel furnaces, copper flotation work, copper converters, copper or lead furnaces, atomizing of oil, boosting of gas, and other types of service requiring a large volume of air.

It has often been remarked that it is not commercially possible to build a centrifugal blower for pressures of 25 to 30 lb. The fact that this is in every sense a possible proposition is evidenced by the fact that a number of blowers for 100 lb. discharge pressure have been built and installed for supplying air to rock drills, pneumatic tools, and other equipment. For pressures over 30 lb., however, these units are usually designated as turbo compressors and, of course, the greater the discharge pressure the larger the number of stages.

Summing up the above, it is evident that the turbo blower has many inherent advantages. The simplicity of these units makes attendance a simple matter and upkeep cost low. Because of the absence of rubbing surfaces in either the blower or turbine, and the fact that the bearing journals ride on an oil film, the wear and tear is negligible. Operating costs are reduced to a minimum. The steam economy of the turbine does not have to be mentioned here. Added to this is the small oil consumption due to the fact that the complete oiling system is enclosed and the same oil is in circulation continuously without loss, except that which is due to evaporation. The flexibility of the blower is superior to that of any type of reciprocating engine, and of course the floor space occupied is much smaller and consequently the foundations required cost much less.

IN CONNECTION with a study of the flow of heat in coal, being made by the Bureau of Mines at its experimental coal mine near Pittsburgh, Pa., the problem of determining the rate of flow of heat from the ventilation air into the coal at the experimental mine has been attacked making use of a standardized flow plate inlaid in the coal walls of the mine. This plate consists of a sheet of lead ¾ in. in thickness and 3 ft. in diameter. Thermocouples mounted in the opposite faces of this plate enable the operator to determine the temperature gradient across it, and knowing the thermal conductivity of the lead, the quantity of the coal is also computed by using these data, together with the temperature gradient in the coal. This gradient is found by means of a large number of thermocouples which are located at various positions in the mine wall.

U. S. CIVIL SERVICE COMMISSION announces examinations as follows, receipt of applications to close Feb. 6: Mechanical Engineer, $3000 to $5000 a year; Electrical Engineer, $3000 to $5000 a year; Mechanical and Electrical Engineer, $3000 to $5000 a year; Associate Mechanical Engineer, $2500 to $3000 a year; Associate Electrical Engineer, $2500 to $3000 a year; Assistant Mechanical Engineer, $2000 to $2500 a year; Assistant Electrical Engineer, $2000 to $2500 a year. Vacancies in the Chemical Warfare Service, Edgewood Arsenal, Maryland, at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from these examinations. Apply for Form 1312, stating the title of the examination desired.

Health Problems of Industry---I

HEALTH AND EFFICIENCY IN INDUSTRIAL PLANTS; FACTORY VENTILATION AND LIGHTING. BY C.-E. A. WINSLOW

IT IS THE object of industry to produce a maximum product at a minimum cost. The object of public health is to produce a maximum amount of physical well-being, also at a minimum cost. It is probable that 10 yr. ago these two objectives would have seemed to many manufacturers to be unrelated, if not mutually antagonistic. Today, however, both scientific knowledge and practical experience have progressed so far that health and production in the plant are so bound up together that the aims of the production engineer cannot be fully attained unless he takes the health of the worker into account as one factor in his problem.

There are three ways in which insanitary conditions menace production—by reducing the efficiency of the employe while he is actually at his work-bench, by favoring minor illnesses such as cause temporary absenteeism, and by ultimately contributing to more serious disorders or to a fundamental psychological unrest which may lead to permanent separations and high labor turnover.

When we find, for example, that an increase in atmospheric temperature from 68 to 75 deg, may manifest itself in a reduction of 15 per cent in the amount of work performed, as was indicated by the investigations of the New York State Commission on Ventilation, it is clear that it will pay the production manager to look into the problems of ventilation and air conditioning in his factory.

In Chicago a new system of factory lighting was installed by a firm making iron pulleys at a cost amounting to 5.5 per cent of the factory pay-roll. The result was an increase of 20 per cent in production. It will apparently be worth while for the progressive industrialist to study illumination conditions as factors in production.

Recent studies on the incidence of sickness in the United States have shown that the average individual loses between 6 and 7 days a year from illness; or, to put it in another way, that about two per cent of the population of a town, or of the workers on the pay-roll of a factory, are incapacitated at a given time on account of illness. Such illness is due to diverse causes and much of it is due to causes beyond our control; but another very substantial fraction of it can be prevented by the maintenance of hygienic conditions and by the application of sound medical advice.

During the past two decades the whole trend of experience has made it evident that the delicate mechanism which we call the human body is often also the most important machine in the factory and every effort that may be made to select human machines well adapted to their specific tasks, to give them the best conditions under which to operate and to see that they are kept in good repair, will bring rich returns in dollars and cents as well as in health and happiness.

In any industry the plan which, other things being equal, will rank highest in productive efficiency is the one in which such points as the following are given careful consideration in its routine operation: the ventilation of the work-rooms and the regulation of their temperature at a point most favorable to bodily vigor; the lighting of the work-rooms so as to provide adequate general and local illumination and to avoid objectionable glare; the control of harmful irritant dusts which may be discharged into the atmosphere with consequent danger of promoting tuberculosis and other respiratory diseases; the safeguarding of any poisonous substances which may be handled or which give off toxic fumes or dusts; the provision of a good water supply and of adequate toilet and washing facilities; the elimination of all needless fatigue by adjustment of seats and such other working conditions as may exert an influence upon it; and the provision of a factory medical and nursing service for the adjustment of the worker to a job for which he is physically fitted, for the instruction of the force in the principles of personal hygiene and for the prompt detection and preventive treatment of injuries and illnesses before they reach a serious stage.

THROUGH special arrangement with the American Trade Press, Power Plant Engineering is enabled to publish exclusively in this field a series of special articles on the most important health problems of industry, written by Dr. C.-E. A. Winslow, one of the most eminent public and industrial health authorities of the country.

Dr. Winslow, as Health Supervisor of the Safety Institute of America, and as Professor of Public Health at Yale University, has unusually favorable opportunities for studying the health problems of industry and the best current practice in efforts to overcome those problems.

As Dr. Winslow points out, failure to give serious attention to these matters is costing American industry millions of dollars annually in direct loss through such channels as spoilage of materials, compensation for industrial accidents and occupational diseases, lowered production efficiency, and impairment of morals or good will. It, therefore, behooves every industrial executive to read this series.

FACTORY VENTILATION

WHILE THE PROBLEM of factory ventilation is frequently complicated by the presence of poisonous fumes or irritant dusts given off in the course of special industrial processes, at present we will consider only the problems which arise in the ordinary factory workroom where the air is vitiated only by human occupancy and by the combustion of illuminants.

If such work places are badly ventilated the discomfort which is experienced is often attributed to the lack of oxygen, or to the presence of carbon dioxid or some mysterious organic poison. Recent studies have shown these views to be erroneous. The climbers who have striven to scale the heights of Mt. Everest for so many months do indeed suffer at those high altitudes from a lack of oxygen; but in the ordinary occupied room, however badly ventilated, there is always an ample supply of oxygen to meet any physiological need. Carbon dioxid is present in excess in a crowded, badly-ventilated room,

but the excess is never sufficient to exert any harmful influence upon health or comfort. As to the supposedly harmful organic substances, the "crowd poison" once believed to be given off in the breath, they simply do not exist.

It has been demonstrated beyond any question that the discomfort experienced in a badly ventilated room is due not to any subtle chemical influence but to the simple fact that the air in such a room is almost certain to be overheated.

This fact does not make the evils any the less real or important. Indeed it is difficult to overestimate the seriousness of the burden imposed upon industry by a lack of attention to the problems of air conditioning. In the first place, the studies conducted by the New York State Commission on Ventilation have made it certain the actual output of the worker must be directly affected by the atmosphere to which he is exposed. Its careful investigations indicated that an increase in room temperature from 68 deg. to 75 deg. might be accompanied by a decrease in the amount of work performed, amounting to 15 per cent, while a further increase to 86 deg. caused a decrease of 37 per cent. The lassitude and disinclination to active work which directly results from exposure to an overheated atmosphere is less important, however, than the indirect result which manifests itself in increased susceptibility to respiratory disease.

As an essential measure for productive efficiency there should be a thermometer placed in every factory workroom and the task of observing this thermometer at regular intervals should be made a part of the routine duty of the foreman. If the temperature is over 68 deg. an immediate attempt should be made to remedy conditions.

In the majority of cases it is probable that excessive temperatures in the factory workroom are due not to the lack of special ventilating appliances, but merely to the misuse of heating appliances. When such is the case the high temperatures may be controlled, with a coincident saving of fuel costs, by merely turning off radiation or cutting down hot-air supply.

If, on the other hand, the temperature of the workroom rises even when heat sources are properly regulated—as will be the case in a crowded room—the condition must be met by ventilation or the admission of cool air to replace that which has been raised to a high temperature by the heat constantly given off from human bodies. In many instances the flushing out of the room by throwing windows open at noon and perhaps in the middle of the night will be all that is necessary to make conditions comfortable. During the working periods themselves a room which is not too large or too crowded may be kept fresh and well-ventilated by window ventilation with certain essential precautions. There should be radiators placed along the walls under the windows to temper the incoming air and there should be slanting window boards to deflect it upwards and mix it evenly with the air of the room; and there should be exhaust ducts extending from near the ceiling through the roof to carry off the warm air from above.

Use the thermometer first to find out what the conditions are. Use common sense in controlling those conditions by regulating heat sources and by window ventilation. Finally, call in an expert when other measures have failed.

Factory Lighting

It would seem reasonably obvious that the worker cannot perform his tasks efficiently unless he can see what he is doing; and yet there is perhaps no field of industrial hygiene in which sound principles are more often violated. As a result, the worker suffers from eye-strain and headache, or from one of the many disorders which have their root in eye-strain, and the industry suffers from misplaced motions and often from damaged work.

There are two cardinal principles to be observed in the art of industrial plant illumination. It is first of all necessary to provide an illumination that is adequate in amount; and it is equally essential to avoid glare and to make sure that the work upon which the eyes are to be fixed should be the best lighted object in the field of vision. Contrast effects play a large part in vision and the eye adapts itself to the most brilliant part of the field before it.

As with the problems of ventilation, discussed under the preceding heading, the application of common sense will make it possible for the factory executive to detect many instances of faulty lighting, and this is particularly true with regard to the problem of glare. Under conditions of natural, or daylight, illumination inspection will often make it clear that the arrangement of work tables, as in the case cited above, is such as to throw a direct glare into the eyes of the worker; such a condition may usually be remedied by rearrangement of work benches or by the provision of shades. The latter should pull up from the bottom and not down from the top since it is often desirable to protect the workers near the window from the glare of the lower sash while preserving the light of the upper sash for those further away. In the case of artificial lighting, too, it is easy to discover cases in which unshaded lamps or lamps with improperly designed shades or placed at an improper height or distances are producing direct glare. One case comes to the mind of the writer in which the lighting was enormously improved, both as to shadows and as to glare, by placing the lighting units over the heads of workers instead of over the benches themselves.

In regard to the problem of adequacy of illumination the factory executive will find the American Standard Code of Lighting, approved by the American Engineering Standards Committee and published by the Illuminating Engineering Society (29 West 39th St., New York City), an invaluable aid.

Illumination is measured by various instruments, of which the most convenient for one who is not an expert is the foot-candle meter. The foot-candle meter is sufficiently accurate for ordinary purposes and is so simple that any one of average intelligence can easily learn to use it. It is wise policy in any industrial establishment of reasonable size to obtain one of these instruments and to train someone to check up at regular intervals on the actual performance of the lighting system in use in various workrooms.

Periodical surveys of the actual lighting conditions in industrial plants will, on the one hand, reveal deficiencies which are tending to hamper work and to injure health, and on the other hand, will often indicate excessive illumination and point the way to substantial economies. If made in conjunction with a study of electrical current consumption such a lighting survey will be use-

ful in indicating the relative efficiency of various types of illumination and in a large plant will often suggest the economic value of a detailed study of the whole problem by a competent expert in illuminating engineering.

Finally, a word should be said in closing about the importance of the factor of upkeep in factory lighting. The illumination obtained in the workroom during daylight hours will be largely controlled by the cleanliness of windows and the extent to which light is reflected by light tinted walls. Where artificial illumination is used the replacement of burnt out fixtures and the cleaning of lamps and reflectors play an equally important part. The Code of lighting cites one case in which the intensity of illumination in a given factory was increased 80 per cent by replacing burnouts and then increased 90 per cent more by cleaning the lighting units. What are the conditions of the lighting system in your plant?—(Copyrighted by American Trade Press, 1923.)

Use of Argand Type of Blower for Clinkering Coals

COMBINATION STEAM AND AIR BLAST PENETRATES STRATA OF SLAG FORMED WITH INFERIOR COAL

IN ORDER to burn the smaller sizes of either hard or soft coal, it is generally recognized that a forced under-grate blast should be used to obtain the best results. One method of producing this under-grate blast is by means of steam jets. One of the reasons for employing this means is that with coals that tend to clinker,

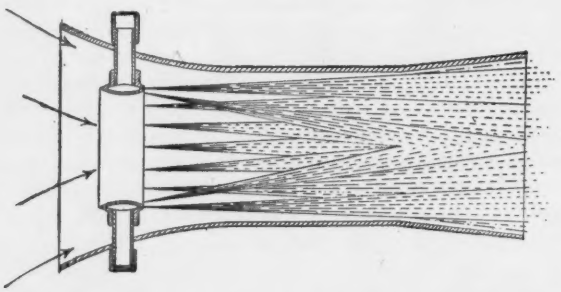


FIG. 1. LONGITUDINAL SECTION OF HIGH DUTY MC CLAVE ARGAND BLOWER SHOWING HOW STEAM JETS MIX WITH AIR

the all-air blast will cause the clinker to form in more or less compact slabs through which the air has difficulty in passing, while the combined air and steam blast will tend to keep the clinker comparatively soft and porous so that the air can percolate uniformly through the whole bed of fuel.

Another effect of the steam is to cool and coagulate the fine ash in the lower strata of the fire, which prevents its being blown up into the burning section where its presence is undesirable. Another feature of a properly proportioned combined air and steam blast is that each furnace has its own blower which permits of easy individual control.

Ordinarily this type of blower, which is shown in section in Fig. 1, is furnished with a regulator which automatically controls the steam supply to the blowers, so that when the steam pressure reaches the desired point, the steam supply to the blowers is shut off, and as soon as the pressure drops, it opens up.

When the blower is designed to go through the side wall of the ash pit, it should be set about midway between the back ash pit wall and the inner edge of the dead plate, the top of the discharge end being about 11 or 12 in. below the top level of the grate. When the blower is designed to go through the bridge wall an

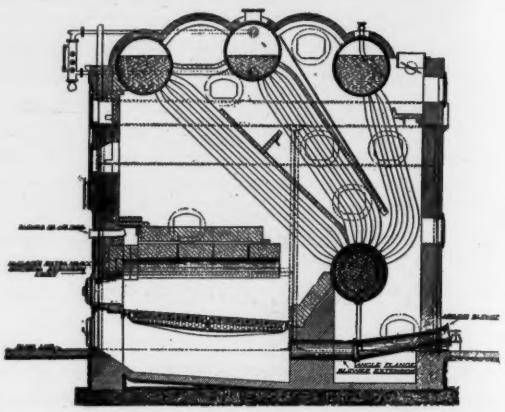


FIG. 2. METHOD OF INSTALLING ARGAND BLOWER IN REAR WALL WITH EXTENSION RUNNING THROUGH REAR AND ASH PIT WALL

installation such as shown in Fig. 2 is to be recommended. The steam supply pipes should be from ½ in. to 1¾ in., depending on the size of blower used, and should always be connected with the top of the main steam pipe or the dome of the boiler.

When a pair of blowers is placed in the same ash pit, the supply pipe should run from the top of the main steam pipe or dome of the boiler down to a point just above the pair of blowers, and a branch should lead from the supply pipe to each blower. The control valve should be placed in the main pipe in order to control the steam supply into both blowers simultaneously. This arrangement of pipes and valve is necessary regardless of where or how the blowers are placed.

In operating the blower, the blast may be regulated to suit requirements by the valve in the steam supply pipe. There is generally more or less scale and dirt in a new steam pipe, hence it will be necessary for the first few days after installing the blower to clean out the holes in the blower ring frequently, and also to open the blowoff cock, located on the opposite side of the steam connection to the ring, for a few seconds, so as to clean scale and sediment out of the steam chamber in the ring. The steam should be turned on when cleaning the holes in the blower ring, as this will locate the position of the holes. A wire hook should be used for the purpose of cleaning out the holes in preference to any sort of tool which may make the holes larger or ream them tapering, which will materially lessen the efficiency of the blower. In order to get full capacity from the blower, all of the holes in the blower ring must be kept open; therefore the ring should be examined occasionally to see that each jet is blowing freely.

In all cases where anthracite coal is used for fuel, it should be sprinkled with water before putting it on the fire, not enough to make it sloppy and heavy, but just sufficient to make the dust adhere to the particles of

buckwheat. Anthracite screenings from coal yards should be treated in the same manner, and if it has been out in the weather for any considerable length of time, it will be found advantageous to mix it with about one-fifth its bulk of bituminous slack, if such is available.

In burning fine fuel, a simple, yet important feature, when such blowers are used to furnish blast, is to close the damper in the chimney or stack to a point where the burning gases will not blow out through the fire door when opened, for where there is a strong chimney or stack draft in connection with the under-grate blowers, a large percentage of the gases may escape without igniting. Therefore, it is advisable so to regulate the damper that the largest possible volume of flame may be produced in the furnace.

What Are Essentials for Success in Steam Engineering?

By R. Cederblom

ON A VISIT to an engine room, I found the chief and his assistant busy cleaning out an oiling system. Stopping work for a minute to greet the visitor, he turned to the assistant and told him to remove a piece that was held by a couple flat head countersunk screws. The man picked up a screwdriver that had seen better days and had a point that looked like the one shown in Fig. 1, and went for those screws. They were hard to start and at the first attempt, the tool promptly slipped out of the slot, rounding off the corners. I heard him swear as he tried time and again, using most of his strength now trying to keep that point down in the slot, still at every turn it slipped out and chewed off some more of those corners.

By the time he finally gave up and told the chief that the screw was in there to stay and would not budge, the head of that screw was a sorry looking affair.

Without saying a word, the chief just took one look at the situation, went over to the workbench and picked up a small chisel which he trimmed to suit and cut a new slot in the head of that screw. He then took the same screwdriver over to the emery wheel, grounded off the sharp point and dressed the sides so as to get a snug fit, as shown in Fig. 2. By means of a small monkey-wrench applied to the flat sides of the tool, he gave it a twist and that screw came out with very little effort.

Watching the whole performance, I could not help thinking: That assistant will never make a successful engineer. The chief, on the other hand, was a man whose mind could see things from a practical point of view, and a glance at the situation told him that a good grip on that screw in its present condition was out of question, and he promptly altered conditions to suit requirements.

If he had been asked to explain just why the other man failed, he might not have been able to do so; but for all that, he got results, which is all that counts after all.

Of course, the reason was the V-shaped point on the screwdriver. If we have a V-shaped block resting on a flat surface, as shown in Fig. 3, anyone knows that a force bearing down on this block in a vertical direction will slide the block sideways.

With a V-shaped point on a screwdriver, we have exactly the same conditions, only the force is horizontal and the wedge or tool is lifted out of the slot and the greater the twisting moment, the greater the force required to hold it down in the slot. With a point such as the chief used, the sides of the slot and the tool are parallel and no matter how great the twisting moment, there is no resulting force in any other direction, and while the assistant used most of his strength to keep the screwdriver from climbing out of the slot, the chief's efforts were 100 per cent efficient.

This incident suggests the question: What is that most essential "something" in a man's make-up that leads to success in the steam engineering field?

No doubt many a young, ambitious engineer has asked himself that very question on visiting some large modern plant, wondering how the man in charge landed such a position.

It would be interesting to hear the opinion of other readers on this subject. Some will say hard work, study of engineering principles and applying the knowledge in a commonsense, practical way.

Now that goes a long way toward success, nevertheless it has failed to land many a man at the top.

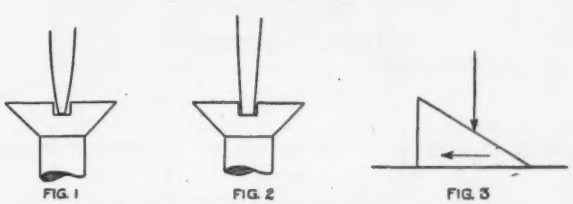


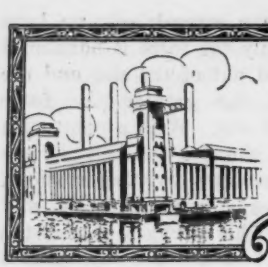
FIG. 1. POINTED SCREWDRIVER RIDES SLOT
FIG. 2. SCREWDRIVER POINT WHICH HOLDS
FIG. 3. FORCES ACTING BEVELED SCREWDRIVER END

One young man of the writer's acquaintance tried his level best to make good and did make a good record as assistant in a large plant, on the strength of which he was offered a responsible position in charge of a new plant. He was familiar with all the details of the equipment of this plant, knew what results he ought to get, still was unable to produce and as a chief was a failure.

I know of a chief engineer, capable, well educated, knows engineering from a to z, who has held the same responsible position for years, but he has to be on the job practically 24 hr. a day to keep his plant running. A good man won't work for him, and what help he does get needs watching. As a steam engineer, I think he has missed his calling.

I know of other plants, well organized, where every man knows that his best efforts are appreciated and the plants are operating smoothly day after day, no matter whether the chief is on the job or not.

Men in charge of our most important power plants of today are not by any means all college graduates; but with many of the thousands of graduates turned out of the technical colleges every year taking up power house work as a profession, will the young fellow with only a common school education, trying to work his way up from the ranks, stand as good a show today as in years past? In the writer's opinion he can, but he must possess or develop certain necessary traits to land at the top and be considered a success after he gets there. What are they?

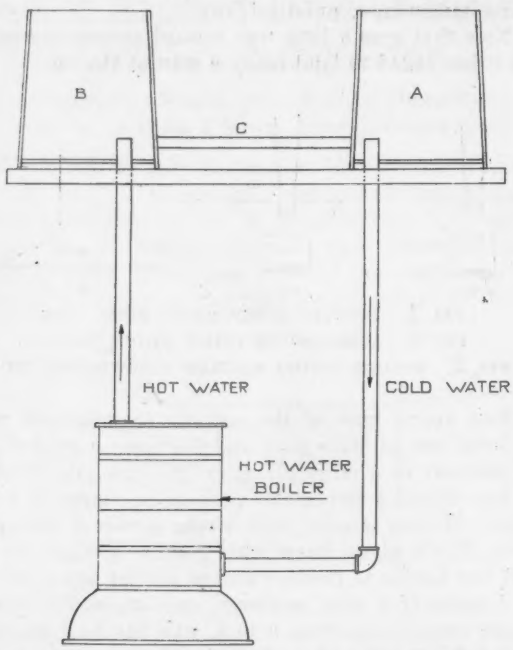


LETTERS DIRECT FROM THE PLANT

Increasing the Supply of Hot Water

In a large steam laundry where much hot water is used which is heated by exhaust steam from the engine, live steam had to be used also at times, as there was not enough exhaust steam to heat the large amount of hot water sometimes needed.

The power plant consists of one high-speed engine and one boiler. A short time ago a new steam using



ARRANGEMENT OF TANKS AND HOT WATER BOILER FOR INCREASING HOT WATER SUPPLY

apparatus was installed in the laundry which used considerable live steam, making it impossible to use live steam also for heating water. This was due to the fact that the boiler was too small and was unable to keep up the steam pressure.

As the hot water was needed badly and as there was not room to install another boiler or one of a larger capacity, it was decided to get out of the difficulty in the following way: There was a large hot water boiler in the yard which had been used some years ago for heating a number of rooms in the plant. After an examination and a cold water test, this boiler was found to be in good condition. The hot water tanks, of which there are two in this plant, are elevated quite high so as to get sufficient water pressure in the water using apparatus. They are arranged as shown in the illustration. Cold water from the city mains runs into the tank A, from there into tank B through pipe C. In tank B, the water is heated by the exhaust steam and from there the water is supplied to the water using apparatus.

As shown in the illustration, the hot water boiler was located under the tanks and a pipe was connected from the bottom of the cold water tank into the bottom inlet of the hot water boiler. Another pipe was connected from the top outlet of the boiler into the bottom of the hot water tank. In this way, cold water runs into the bottom of the boiler, comes out hot at the top outlet and runs into the tank. With a good fire in the boiler, the water is quite hot when it enters the tank.

This arrangement enables the exhaust steam to furnish sufficient water at all times, no matter what amount is used in the plant. A fire is also left in the boiler during the night and the water keeps on circulating through the boiler all night from one tank to the other. Thus the water is quite hot in both tanks the next morning.

With this arrangement it was not necessary to install a larger boiler or to add another one to the one already in the plant in order to increase the supply of hot water.

This all was obtained with but little expense and trouble by merely doing a little thinking.

It shows what can be done at times to get out of some difficulty that may come up in any plant.

H. A. Jahnke.

Assumption

If some of the men who design heating systems for factory, and loft buildings, were to sojourn for a while during zero weather to some engine-room, and listen to complaints about the lack of heat, and watch the poor engineer hustle to jack up the back-pressure in an attempt to try to stop the complaints, they might get wise to some of the weak spots in their systems, and instead of "assuming" conditions, figure on those that actually exist. I have before me a book on steam-heating, in which the word "assumed" is used four times in one paragraph. It does not look as raw as the word "guessed," but in this connection it means the same. It is "assumed" that steam, at a certain pressure, has a velocity of so many feet per second. It is "assumed" that the pipe friction will be a certain amount. Finally, if the system is installed according to specifications, it is "assumed" that sufficient heat will be supplied at all times. Then the room is measured, the amount of glass figured, and the amount of radiating surface determined for conditions as they appear, at the time. Usually no provision is made for additional heat.

We will suppose that a large loft has been rented for manufacturing purposes. A row of offices are partitioned off along the walls by the windows. The people working in these offices get too warm, and close the radiator valves, while the interior of the loft is still too cold, consequently, more radiators have to be installed. Now, to save pipe-cost, the risers are ordered just large enough to supply the original layout of radiation. Perhaps your supply pipe has to pass through a long, cold basement, and along a wall, over the tops of windows, with sashes leaking cold air, so that by the time steam reaches the radiators it is mostly water, and not too hot at that. Also, allowance should be made for leaky window sash in the rooms, and the constant flapping of doors, as people are constantly passing in and out. It is easy enough to close radiator valves if a person gets too warm; but if he gets too cold, his only recourse seems to be to call down the engineer.

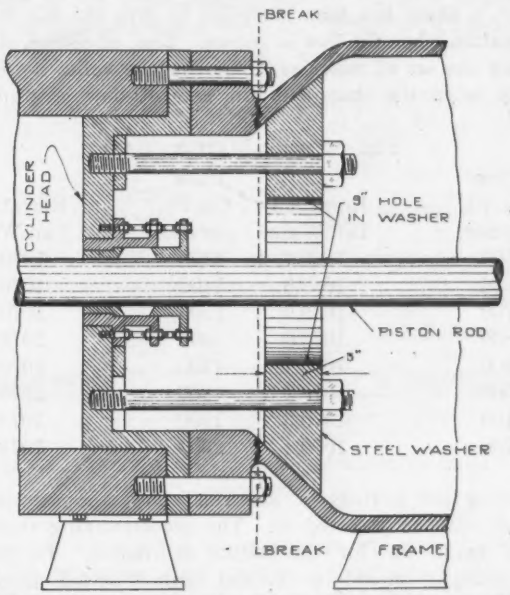
In a new loft building in New York City, it was "assumed" that a 14-leaf 26-in. radiator, placed on the ground floor, in a 15 by 15 ft. stairway, 12 stories high, would furnish sufficient heat for that space. There is a 4-in. sprinkler riser, and a 4-in. fire line in the stairway, and it is needless to say, they both froze up and burst the first winter the building was used. After this experience another radiator, like the first, was then installed on the sixth floor.

A small textile mill near where I live, is run by water power, and steam from a 72-in. by 18-ft. boiler is used only for dyeing, drying, pressing, and heating the building. The heating coils, and radiators seem to be well planned, but a 15 by 28-in. return tank receives the discharge from seven steam traps, of different types and sizes. A duplex boiler feed pump takes its supply from this tank, itself, exhausting into the atmosphere. A 2-in. line from the dam supplies the make-up water, which is controlled by hand by a globe valve. A float in the tank actuates a regulating valve to stop the pump when the tank is empty. Now, the fireman regulates his make-up water, and then attends to his other duties. Some one shuts off steam from some part of the work, and the next time the fireman goes around to the pump, he finds ice-cold water going into the boiler. This happens many times a day; nights and Sundays, there are not enough returns from the heating system, alone, even to warm the feed water. But when all the different processes are using steam, the 2-in. overflow from the tank is running full to waste. There is an old boiler there which they say leaks badly. Is it any wonder? A hot water storage tank could be installed there, at small cost, but the management seems to think it unnecessary.

Oftentimes, when some simple changes in equipment, or improvements are contemplated, an expert is called in for advice, or to plan the work, when the man in charge, being familiar with the plant, could do it as well, and perhaps better, and at less cost, if given the chance. Besides, it would furnish an incentive for him to keep "on his toes." M. M. Brown.

Repair of Broken Engine Frame

We have in our plant a 20 by 36-in. Corliss engine which operates under 150 lb. pressure and runs at 100 r.p.m. Recently the frame of this engine cracked and broke apart immediately adjacent to where it is bolted to the cylinder head. The accompanying sketch shows how a repair was effected. I had a new cylinder head of extra thickness cast and in this head I drilled and tapped for 1½-in. studs six equally spaced holes. I then made a steel washer 3 in. thick and beveled it as shown to fit the inside of the frame. A 9-in. hole was cut in the center to allow for the removal of the piston rod, stuffing-box, and six holes were drilled to allow the



HEAVY WASHER HOLDS ENGINE FRAME AGAINST CYLINDER HEAD

cylinder head studs to project through. I then put nuts on the studs to project through. I then put nuts on the studs and drew them up tight, thus drawing the frame and cylinder head together. This repair was made about 3 yr. ago and since then the engine has been in constant service without having given us any trouble whatever.

T. R. McBride.

Measuring Overhead Piping; a Disadvantage of the Ring Gasket

In factories and mills it is often necessary to run pipe lines overhead on the trusses or ceilings. To avoid climbing around overhead, we sometimes attach 15 or 20 ft. of twine to a plumb bob, drive a couple of small nails in the end of a 10-ft. pole and transfer our overhead measurements to the floor, where we can take them off and cut the pipe out before going up a ladder, thus avoiding a part of the danger of climbing about the running machinery. We admit that this is a lazy man's scheme, but it serves well where only ordinary accuracy of measurement is called for.

It is regarded as good practice to use ring gaskets between flanges and no doubt it is, but it has its weak points like nearly everything else. In my younger days, two of us engineers in an ice plant, broke a flange 3 in. thick by screwing the bolts up too hard on a ring gasket It was poor judgment on our part, of course, but it proved it could be done and we have never forgotten the experience. I also have a suspicion that sometimes it has a tendency to pull the threads of the flange away from those of the pipe. J. O. Benefiel.

Use of Chart in Measuring Tail Water

At the Twin Falls hydraulic station of the Peninsular Power Co., no tail water gages or measuring sticks are used during periods of normal river flow. As the flow in cubic feet per second is recorded each hour for both the turbine wheels and the waste gates and as the head in the tail race depends on the previous and present flow, a chart has been compiled to give the tail water elevation when the flow is known. This, of course, eliminates one set of readings. The chart is valid, however, only when the change in the rate of flow is gradual.

TAIL WATER ELEVATION CHART

Flow Cu. Ft. per Sec.	Elevation Tail Water	Flow Cu. Ft. per Sec.	Elevation Tail Water
500	1069.7	1300	1070.5
600	1069.8	1400	1070.6
700	1069.9	1500	1070.6
800	1070.0	1600	1070.7
900	1070.1	1700	1070.8
1000	1070.2	1800	1070.9
1100	1070.3	1900	1071.0
1200	1070.4	2000	1071.0

During the periods of abnormal flow, the measuring stick must be resorted to. The accompanying chart is one made up for the station mentioned. To insure accuracy it should be checked against actual measurements at intervals. L. W. Wyss.

Some Observations

In traveling around, visiting various engine rooms, one often sees many "kinks" and good ideas, which are not found in books; likewise, on the other hand, many little practices and troubles which swell the grief column.

At our place there were two Corliss engines—a large and a small one. When it is necessary to run the small one in parallel with the larger, part of the load is cut out until the engines are in on the board together. Upon asking why it was done, I was told that that had been the practice with the electrician—who was then on a vacation. I do not think this procedure was necessary, as another electrician was able to synchronize the two machines without cutting out any of the load.

On one of these engines a dashpot, with a pipe running from the compression chamber, down through a cement floor, and into what, nobody knew, was giving trouble. After the pipe was disconnected, the pot worked much better, showing that the line was plugged up somewhere, causing considerable back pressure.

Some work had to be done to a vertical compound engine. There was a knock in the low pressure crankpin box. To remedy this trouble, the box was tightened and the engine started up. It ran better from the standpoint of noise, but the pin heated up quickly. Subsequently the box was dismantled and the pin examined. It was found to be somewhat larger at the outside end. As the pin was hardened it could not be touched with either chisel or file, so the following scheme was used. A 1-in. hole was drilled and tapped in the center of the pin and into this was screwed a 1-in. rod. A hand-driven emery wheel was clamped to the rod and so adjusted that a light cut could be taken on the large end of the pin. The emery wheel was then turned, and at the same time the rod was screwed in and out, to true up the pin. Since then it has occasioned no trouble.

There seems to be a common tendency nowadays to give an engine a great deal more load than it was designed to carry. This is seen more on the older engines that were built before the higher steam pressures were so widely used.

One of these engines was recently met with. Originally it had one eccentric, made about 80 r.p.m. and, used at low steam pressure, probably 100 lb. It is now equipped with two eccentrics, using a higher pressure, and running faster, with a longer cutoff. The idea is this: In the design of the engine the parts were made strong enough, with a margin of safety, for a certain load. This load has now been greatly increased, consequently the strains and stresses are greater. The bed weaves under the load, and it is harder to keep firm on the foundation.

Another old engine has been greatly overloaded and more load yet was destined for it, but was not put on, as the firm was advised it would be dangerous. The bed was of a girder frame type, and at every stroke the upper guide sprung. Tom Jones.

Cleanliness and What It Will Do

One of the important considerations in the upkeep of a steam plant is, or should be, the matter of cleanliness. It is surprising just what cleanliness will do to a plant.

I have in mind a plant of some size, located in a paper mill town in the State of Maine. The condition as far as cleanliness went was past description. My business in this plant was the inspection for an insurance company of the mechanical equipment, and I found the job about the dirtiest I had ever tackled, and that's saying something. After spending a week upon this job, however, I began to get interested in it, and the idea came into mind that it might be of some value for me if I made a list of those items that could be improved by cleanliness, in fact, to turn this matter in as a part of my report.

The system I used in making this report was as follows:

There were two engines of a well known make, of a type that has a lot of nickel and brass work upon them. These engines can be made to look pretty nice. There was brass railing all around these units, which had been painted with a heavy tar paint, black and sticky. At the time of my visit, the rails were haired out like a cat.

There was a small instrument board on which were some 27 instruments of various types, 19 of which were without glass. Practically all of the instruments were nickel-plated, but it was hard work to know it; it could not be told by observation. Half the instruments were out of order, due wholly to their filthy condition. The floor was hardwood, in very good shape but very dirty.

The chief engineer's office was enclosed by an all-glass enclosure consisting of 120 panes of glass, of which 78 were broken or out of place. The top of the chief's desk was piled high with magazines, books and catalogs, etc., and just what was there nobody knew, not even the chief, and I do not think he cared. The desk itself was

a junk pile, and if the chief wanted a pencil it took at least 15 minutes for him to find it on his desk.

There was a good bookcase in the office that was given over to forming a receptacle for broken fittings, pieces of scale and other junk. The room itself was half full of junk—2 bbl. of sal soda, two bales of waste, all sorts of broken fittings, and part of a broken pump.

This was the general condition of everything in the plant. I turned my notes on this matter into the office of our assured and into my own office, and thought no more of the matter. However, about 6 mo. later the assured sent me a personal letter, asking me to make out a report covering exactly what should be done to make conditions cleaner in their plant, and what saving would be made by doing this. They also offered me the job of supervising the work, a job I should have liked.

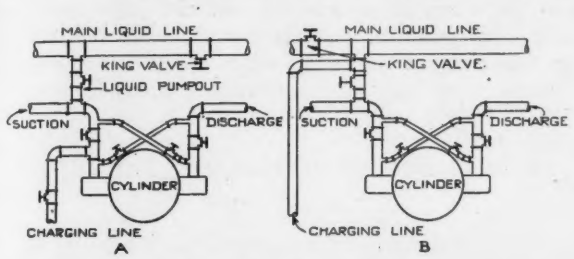
As this was impossible, I made out a list of suggestions from my note book, relative to what should be done, and sent it to our assured.

Six months later I visited this plant, and was informed by the management that the cleaning of the instruments alone had effected a saving that had paid for all the cleaning performed in the plant.

So much for cleanliness. ARTHUR D. PALMER.

Change in Ammonia Piping to Simplify Charging

RECENTLY I took charge of a direct expansion electrically driven refrigerating plant in which the compressor piping was laid out as shown in (a) of the accompanying illustration. It can readily be seen that



COMPRESSOR PIPING WAS CHANGED FROM THAT SHOWN IN *a* TO THAT IN *b* TO ALLOW FOR CHARGING THE SYSTEM ON THE HIGH SIDE

in order to charge the system I had to pump down and then close the main suction valve. In the meantime the refrigerating effect is almost entirely stopped, the low side pressure builds up and the store rooms warm up. I immediately changed the piping as shown in (b). Here I lose the benefit of the liquid pumpout line but this may still be used, closing all expansion valves at the coils. There is another main king valve in this line at the receiver on the roof. As piped in diagram (a) I can charge by closing the king valve and running the new charge through the system instead of through the compressor, and I believe I get better results.

R. G. SUMMERS.

Exhaust Manifold Repair

SOME TIME ago the exhaust manifold on a locomotive, having been inadvertently left out in freezing weather with water in it, froze up and a section of the wall was broken away. After several unsuccessful attempts were made to weld on a new piece, the following repair was made. The manifold is of square section and made of cast iron, and a hole 6½ in. long by 1½ in. wide was broken out in one wall. I took a piece of plate steel ½ in. thick by 2 in. wide and 7 in. long, shaped it to the inside of the pipe and then drilled two ½-in. holes, as shown in the accompanying sketch. I then made up another similar piece to serve as a bridge on the outside.

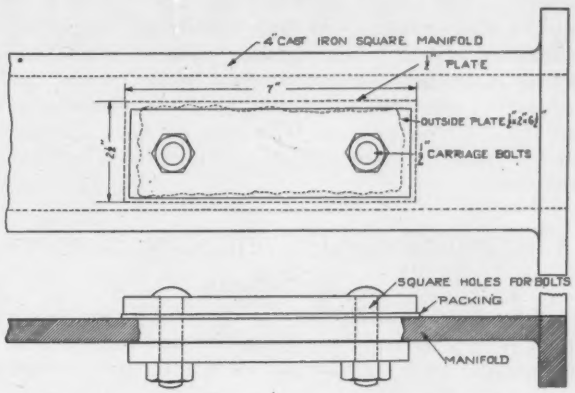


DIAGRAM OF REPAIR MADE ON A LOCOMOTIVE EXHAUST MANIFOLD

After having put the inner piece in the pipe, I packed it with asbestos string packing. Over this I placed a sheet of zinc to protect the packing from the rough inner surface of the pipe. By bolting the plate through to the bridge, a steam-tight joint was obtained. The principle is the same as that of a handhole or manhole plate on a boiler. G. HUHNDORF.

The Bystander's Point of View

NOT LONG ago while a friend of mine was doing some work, I criticized, in a friendly way, the method he used and told him how I would go about it if I were the right kind of a mechanic. Said he, "Come on, let's see you do it yourself." I had to admit that I could not do the work, as it was of a nature which I had never attempted. I insisted, however, that he try out my suggestion. Just to please me he did and was surprised to discover that the greenhorn's method was better than his own.

You, Mr. Reader, though you may not consider yourself an authority on engineering matters, may see ideas, suggestions and descriptions in your power plant journal which you believe might be questioned or improved upon; but you let the matter rest because you believe that the writers of these articles understood engineering better than you do. Put your ideas down in writing and see how they look.

Here is the idea: You may not be able to build a straight brick wall, but you certainly would know if it were crooked or out of plumb and you could point out the defect to any first-class wall builder. So it is in the power plant. You may be able to point out mistakes in an article you are reading even though you might not have been able to write the original article.

If you have not the ability, training or experience to turn out an original design but do have, what is possibly of equal importance, the ability to see faults in the

designs of others, when you see something in the works of others that you think is not just right, are you playing fair with your brother engineers by withholding your comments?

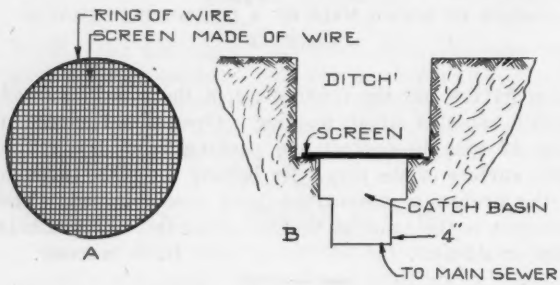
In my opinion, the editor of a technical journal would be glad to have letters of constructive comment from his readers on articles that he publishes.

JOHN THORNE.

EDITOR'S NOTE: Mr. Thorne is quite right in his opinion. The editors of Power Plant Engineering are always glad to hear from their readers on any subject connected with the engineering of power plants; comments and questions on articles, letters, kinks, and answers to questions brought up by other engineers, are always of interest to them. One need not be of a literary turn of mind to write such letters; the idea is the main consideration.

Clogged Sewer Prevented by Removable Screen

IN A large laundry they used to have trouble with their sewers getting clogged up with lint and other foreign matter from the wash-machines, making it necessary



REMOVABLE SCREEN AND ITS LOCATION IN CATCH BASIN

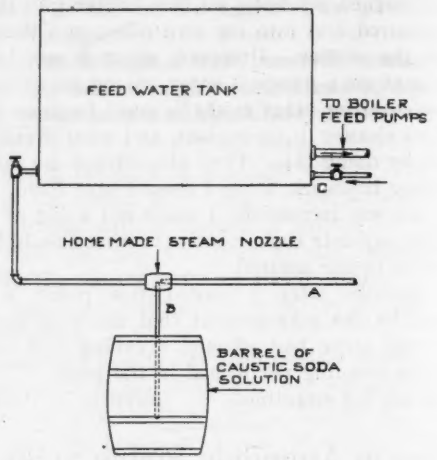
at times to shut down the plant until the sewer was clear again. At times it was necessary to dig up the sewer and break one or two sections of the pipe to get at the obstruction, then replacing the broken pipe with new pipe. In this way, much time was wasted.

To overcome this trouble, it was decided to use a screen of the type shown at A in the sketch. The type of ditch into which the wash-machines discharged the soap suds and water is shown at B, which also shows how the screen is placed over the catch basin.

This screen has to be removed about once every hour, when it is nearly closed up with lint and other foreign matter from the wash machines. As it takes some time to remove the lint from the screen, and during this time much lint and other matter is liable to get into the sewer, a number of screens are provided. When one is removed, which is done by means of a hook, another one is put immediately in its place. In this way there is little danger of any foreign matter getting into the sewer and clogging it up. The screen which is removed from the catch basin is cleaned when there is the time, ready for further use. H. A. JAHNKE.

Feeding Device for Caustic Solution

AT THE Borden malted milk plant at Elgin, Ill., spring water is used for boiler feed. This water contains considerable quantities of temporary hardness which is removed before the water is admitted to the boilers. By mixing caustic soda with the spring water, excellent results have been obtained in keeping scale formation at a minimum. The simple method of feeding this solution into the feed water tank is shown in the accompanying sketch. The feed water tank is overhead, but for convenience of preparing the caustic solution, the barrel



SIMPLE METHOD OF FEEDING CAUSTIC SOLUTION INTO FEED WATER TANK.

containing it is located on the floor level. From this barrel the solution is elevated to the feed water tanks by means of a home-made steam aspirator, as shown. To keep the water in an agitated condition while the solution is being added, a nozzle is provided in the side of the feed water tank through which steam is injected.

FIELD EDITOR.

Belting Serves as Bearing Lining in Emergency

IN OUR plant we have only one crusher used for icing refrigerator cars and there is no other means of crushing ice for the cars when this goes down. One hot summer day I was notified that the crusher would not run. I immediately went to the icing dock to find why the crusher would not run. The crusher roll was 30 by 36 in. and weighed about 400 lb. A hasty examination showed the cause of the trouble. The drum shaft had run dry for days and had wiped all of the babbit out of the bearing, wearing down into the cast-iron box about ¾ in. The shaft was badly scored and grooved. This had lowered the drum so that it finally struck the decking below and it had just naturally stopped. Cars were waiting to be iced and it was impossible to do anything but a makeshift job.

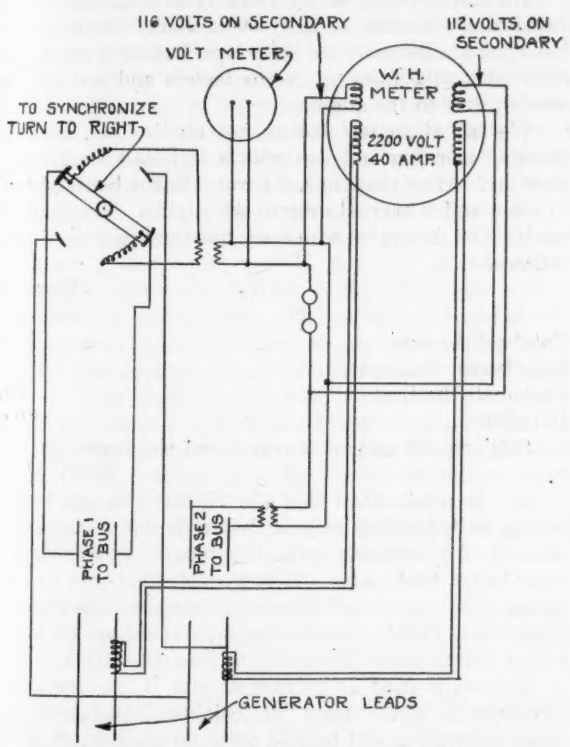
After loosening up the bearing caps, the drum was raised with a set of falls, and two thicknesses of heavy leather belting were slipped in under the shaft. This had been well soaked in oil. The shaft was filed as smooth as possible. The machine was then assembled and ran without trouble till the next Sunday, when I was able to dismantle the crusher, put in a new shaft and rebabbit the bearings.

H. M. TOOMBS.

PROBLEMS IN OPERATING POWER EQUIPMENT

Watt-hour Meter Operation

In the accompanying sketch there is shown a diagram of connections to a watt-hour meter. I would be pleased to have some of the readers of Power Plant Engineering explain why this meter runs faster on one phase



SHOWING METHOD OF CONNECTING WATT-HOUR METER

than on the other. It will be noted that there is a double throw switch at the upper left-hand corner, which enables the operator to get the voltage of the line and the voltage of the generator when synchronizing. After getting the generator on the line, the switch is turned to the left so that the current coil and the potential coil of the wattmeter will be one and the same phase. L. L. P.

Repair for Small Fire Box Boiler

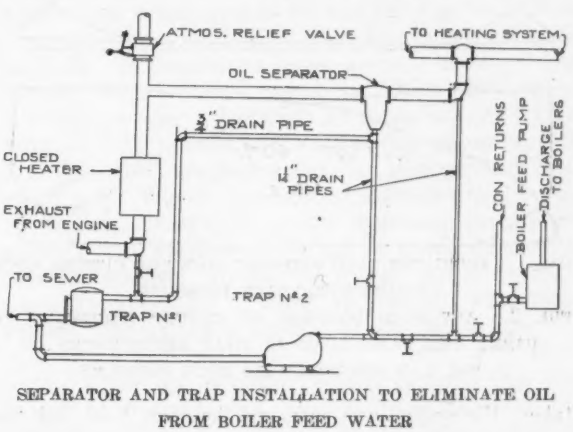
We have a small 10-hp. fire box boiler having a grate 26 by 32 in. For a distance of about 2 in. above the foundation ring, the inside walls are extremely thin; there are even a few small holes in certain places. It is practically impossible to patch this section; about the only repair possible is to cut out the defective 2 in. and raise the foundation ring by about 4 in. This, of course, would entail considerable expense.

Owing to the fact that the plates are perfectly good above the defective strip and that all the stay bolts are in good condition, it has occurred to me that I could effect a repair by filling the water leg with cement to a depth of about 4 in. above the foundation ring. Would such a repair be effective or justifiable under these circumstances? I would appreciate having the opinion of Power Plant Engineering readers on the question.

C. K. D.

Elimination of Oil from Boiler Feed Water

In the Jan. 15 issue of Power Plant Engineering, on page 1223, J. A. B. inquires as to how he can eliminate oil from his boiler feed water. My suggestion would be



SEPARATOR AND TRAP INSTALLATION TO ELIMINATE OIL FROM BOILER FEED WATER

that he install some good make of oil separator in his exhaust line. The system shown in the accompanying sketch is one that is giving good results for me.

Some years ago, on inspection we found considerable quantities of oil in our boilers and subsequently our insurance company sent in a report stating that we would have either to install a new oil separator or trap the heating returns to the sewer. As the latter method would have entailed a big waste of heat and was therefore not to be thought of, the system shown in the accompanying sketch was devised.

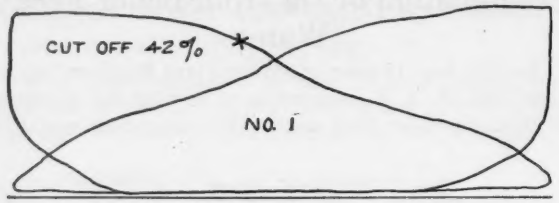
Under the feed water heater is shown a trap which took care of the oil with the old system. This trap became soggy and eventually oil from the engine flowed to the boiler feed pump undiscovered until the boilers were opened for cleaning. The drain pipe shown as No. 1 acts as an oil separator. Any oil escaping No. 2 is arrested by No. 1. At the same time, if the returns are not required for the boilers they can be eliminated through trap No. 2. Oil continually escaping through No. 2 lubricates the valve, causing it to operate without friction. This system has been installed in this plant for about 6 yr. and there is no sign of cylinder oil in our boilers.

When heating is required, valve A is closed and valve B opened. When valve B is closed, all condensate from the heating system is discharged to the sewer.

P. J. MOLLOY.

Effect of Back Pressure on Steam Consumption

TWO INDICATOR diagrams from a 14 by 14-in. high speed automatic cutoff engine are shown in the accompanying illustrations. This engine is used in a furniture factory and the exhaust is used for heating a dry kiln. Card No. 1 was taken with the atmospheric relief valve open so that the back pressure is practically that of the atmosphere. When card No. 2 was taken, the engine was exhausting to the kiln and the back pressure was somewhat greater than 10 lb. gage. I would like to know the effect of this increase in back pressure on the steam consumption of the engine. At the time the two cards were



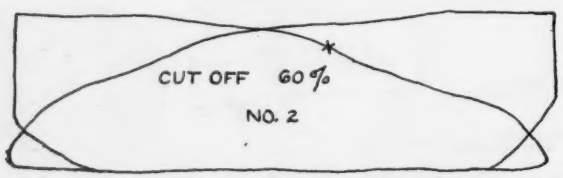


FIG. 1. INDICATOR CARD SHOWING POINT OF CUTOFF WITH ATMOSPHERIC BACK PRESSURE

FIG. 2. ADVANCED POSITION OF CUTOFF NECESSARY TO CARRY THE SAME LOAD AS THAT REPRESENTED IN FIG. 1, WITH INCREASED BACK PRESSURE

taken, the engine was carrying the same load and was running at the same speed. L. W. P.

A. By increasing the back pressure on your engine to supply exhaust steam for the dry kiln, the steam consumption is increased owing to the fact that the cutoff is lengthened. The power output, as shown by cards 1 and 2, is the same in each case, as is also the mean effective pressure as found by intergrating the cards with a planimeter.

It is rather a difficult matter to determine the exact point of cutoff on these cards because there is evidence of considerable wire drawing through the admission valves, and therefore, the point of cutoff is somewhat obscured. It would seem, however, that the cutoff on No. 1 card is approximately 42 per cent of a stroke. On card No. 2 the cutoff is somewhere near 60 per cent. If these points have been correctly ascertained, it will be seen that the increase in steam consumption of No. 2 card over No. 1 is (60—42)÷42=43 per cent. As a check on this figure, we may find the increase in consumption on theoretical basis.

The mean effective pressure is, we find, 41 lb. With atmospheric pressure the mean forward pressure is then approximately 41+15=56 lb. By measuring the card it is found that the throttle pressure is 65.5 lb. gage or 80.3 lb. abs. The ratio then, of the mean forward pressure to the initial pressure is 65.5÷80.3=0.698. If it is assumed that the expansion follows the perfect hyperbolic curve, we find from a table in Kent's handbook that the cutoff which will give this ratio is 33 per cent.

The mean effective pressure of card No. 2 is also 41 lb., but the mean forward pressure is 41 plus the absolute back pressure, which amounts to about 24.5 lb. equals 65.6 lb. The ratio then of the mean forward to the initial pressure is 65.5÷80.3=0.82, and from the table previously mentioned we find that the cutoff is 47 per cent. The increase in the point of cutoff and consequently the steam consumption is therefore (47—33)÷33=42.5 per cent.

Cause of Excessive Foaming

WE HAVE two 72-in. by 18-ft. return tubular boilers furnishing steam for an 18 by 36-in. double eccentric Corliss engine. Recently we have been having a great deal of trouble with foaming in our boilers and water being carried over to the engine.

We can clean our boilers out on Sunday, start up Monday morning and run with a full load for from 24 to 48 hr. After that time, the water in the boilers begins to foam and is carried over to the engine. The chemical analysis of the water which we use for boiler feed is as follows:

	Parts per Million
Total solid matter	332.00
Bicarbonate Radical	305.00
Carbonate Radical	0.00
Chlorine	12.00

Can you tell us how we can avoid the foaming?

W. O. M.

A. It would seem that the trouble you are experiencing with foaming in your boilers is due to the excess amount of bicarbonate radical or temporary hardness in your boiler feed water. It is possible that you are not giving this water the correct treatment. Temporary hardness of this nature may be eliminated by the use of either caustic soda [2 NaOH] or lime [$Ca(OH)_2$].

If lime is used as a reagent, and if the temporary hardness is in the form of calcium bicarbonate, the amount required will be 87.5 parts per million, or, if the hardness is in the form of magnesium bicarbonate, it will require 93 parts per million to precipitate the 305 parts per million as given in your analysis.

If the hardness is a mixture of these two (magnesium and calcium bicarbonate), the amount of reagent will be something between 87 and 93, depending upon the ratio of the two constituents. In this reaction, calcium, sodium or magnesium carbonate is precipitated and should be removed through the boiler blowoff before the concentration reaches the point where foaming is likely to result.

As the hardness of this water is rather high, it will be necessary to blow down quite frequently, a process which is extremely wasteful of valuable heat units. It is to be suggested, therefore, that you use some kind of continuous boiler water purifier in which a portion of the water in the boiler is circulated through a receptacle external to the boiler proper. In this receptacle or tank the velocity of flow is reduced and the suspended matter in the water is precipitated. The filtered water is returned to the boiler and there mixes with the main

body, thus reducing the concentration of the impurities. Such apparatus is described more or less in detail in the Jan. 1 issue of Power Plant Engineering in an article entitled "Removal of Sediment from Boilers."

Change in Steam Quality During Expansion

RELATIVELY COLD cylinder walls caused by the absence of lagging or steam jackets is of course responsible for some condensation in the steam cylinder of an engine. Are there any other causes of condensation, and if so, what are they? J. B.

A. Were it not for the conduction of heat from the steam in the cylinder through the cylinder walls and head, the expansion would be what is known as adiabatic, which by definition means that no heat is given out or absorbed during the process. In this expansion, which is expressed by the equation $p v^n = a$ constant, where p is the pressure, v, the volume and n the ratio of specific heat at constant volume to that at constant pressure; the quality is reduced as the temperature drops, by an amount sufficient to maintain a constant entropy.

Entropy s_1 at the beginning of expansion, is expressed by the equation $s_1 = s_1^1 + x_1 r_1 \div T_1$ and is similarly $s_2 = s_2^1 + x_2 r_2 \div T_2$, where s^1 is the entropy of the liquid, x_1 the quality, r the latent heat and T_1 the absolute temperature. The subscripts 1 and 2 indicate conditions at the beginning and end of expansion. As the total entropy remains unchanged, we have

$$s_1^1 + x_1 r_1 \div T_1 = s_2^1 + x_2 r_2 \div T_2$$

If we assume dry saturated steam at 150 lb. abs. pressure is expanded down to 14.7 lb., we can substitute values from a steam table for all the quantities except x_2. Thus:

$$0.5142 + 1 \times 863.2 \div (358.5 + 459.6) = 0.3118 + x_2 \times 970.4 \div (212 + 459.6)$$

$$1.5672 = 0.3118 + x_2 \times 1.445$$

from which $x^2 = (1.5672 - 0.3118) \div 1.445 = .87$, showing that under these conditions the exhaust will be 87 per cent dry steam.

Steam Flow; Boiler Capacity Required

HOW MANY pounds of dry saturated steam at a pressure of 105 lb. gage will flow through a 6-in. pipe when the velocity is 3000 ft. per min.? A horizontal return tubular boiler is of sufficient capacity at rating to supply steam at 150 lb. gage for a 150-hp. engine of the simple Corliss type operating non-condensing. How much steam will be required per hour? What should be the heating surface of the boiler? What will be the probable coal consumption assuming a reasonable efficiency? J. B.

ANSWERS

QUANTITY of flow is equal to the product of the actual internal area of the pipe multiplied by the average velocity. A nominal 6-in. pipe has an actual internal diameter of 6.065 and the internal area is therefore $0.7854 \times 6.065^2 = 28.9$ sq. in. or 0.2 sq. ft. If we assume that the velocity of 3000 ft. per min. is an average value, we find the quantity of discharge is $0.2 \times 3000 = 600$ cu. ft. per min. As the specific volume of steam at 105 lb. gage is 3.73, the flow expressed in pounds is $600 \div 3.73 = 161$ lb. per min.

2. It may be assumed for the purpose of the problem that the steam consumption of the simple Corliss type engine running non-condensing will be between 25 and 30 lb., say 28 lb. per i.hp. hr. With dry saturated steam at 150 lb. gage the total steam requirements to develop 150 hp. will be $150 \times 28 = 4200$ lb. per hr. At an assumed boiler feed temperature of 212 deg. F. the heat absorbed by the boiler per lb. of steam generated will be $1195 - 212 + 32 = 1015$ B.t.u., 1195 being the total heat of dry saturated steam at 150 lb. gage. The equivalent evaporation from and at 212 deg. F. is then $1015 \div 970.4 \times 4200 = 4410$ lb. per hr. As one boiler horsepower is equivalent to the evaporation of 34.5 lb. of steam per hr. from and at 212 deg. F., the capacity of the boiler will be $4410 \div 34.5 = 128$ hp. At a builders rating of 12 sq. ft. per hp. the boiler will have $128 \times 12 = 153.5$ sq. ft. of heating surface. If we assume an overall boiler and furnace efficiency of 60 per cent, we find that the heat supplied by the fuel will be $4200 \times 1015 \div 60 = 7{,}100{,}000$ B.t.u. per hr. With coal having a heating value of 13,000 B.t.u. per lb. the consumption will be $7{,}100{,}000 \div 13{,}000 = 546$ lb. per hr.

Method of Heating Gas Tank Seal Water

WHAT IS the cheapest and most practical method to prevent the water, used as the seal for a gas tank, from freezing? The tank is 15 ft. in diameter and has a rise of 15 ft. To construct a house over the tank and heat it with steam radiators would cost about $3000, which I believe represents too much of an investment for the purpose. At present, we are blowing steam directly into the water, comprising the seal, through four small steam jets. Would it be economically practical to use city water, admitting it at the bottom of the pit and allowing it to overflow at the top, at a rate sufficient to prevent freezing? During the winter, this water has a normal temperature of about 50 deg. F. The lowest outside temperature is around 30 deg. below zero. J. F. B.

A. There are, of course, several methods that may be used to advantage under certain circumstances to heat the seal water for a gas tank. Where the tank is small, probably not more than 15 ft. in diameter, it would pay to build a housing around it. For very small tanks, such as are sometimes used for laboratory purposes, a non-freezing solution such as alcohol and water, may be used. At some industrial plants where there is considerable exhaust steam available at low cost, this steam is simply mixed directly with the water by some means such as you are at present using. Where water is cheap, a continuous flow of fresh water may be used. The question as to which of these last two systems will be the more economical in the long run will depend on the relative costs of the steam and the water.

It is probable that in the majority of cases, steam is used for heating and in the form of steam coils immersed in the water. The disadvantage of blowing steam directly into the water is that the flow is not easily controlled and quantities of heat are unnecessarily wasted to atmosphere. It will be noticed that where this method is employed great quantities of steam may be seen rising from the surface of the water even on just moderately cold days indicating a water temperature greatly in excess of that of the air. Water temperatures are frequently as high as 50 deg. when 33 deg. would be sufficient. With steam coils, this temperature may be regulated with greater nicety and a saving thus effected.

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Health Problems in Industry

Of all machines in the modern power plant or factory, the most complex, the most delicate and also the most valuable, is the human machine itself. Yet it is often the most neglected insofar as provision for its proper upkeep is concerned.

For instance, it would be considered a case of gross ignorance or extreme carelessness in any plant to permit a high pressure steam line to remain uncovered, or to allow a pump or engine to operate without looking towards its lubrication, or to pay no attention to the draft requirements of the furnaces. Indeed, these things are not even to be thought of, much less tolerated, and any plant owner who discovered such conditions in his own plant would not be slow in calling his engineer in for an explanation. Yet, in many instances, this same owner will permit his men to work in poorly lighted, dusty, unventilated rooms with practically no provision for their personal comfort, and then expect them to work at their highest efficiency.

This tendency to disregard the comfort and hygiene of the employe is not new, but dates back to feudal times when serfs and slaves were given no consideration whatever. But we do not have to go back to feudal times to find evidence of gross negligence with respect to the personal comfort of the worker. The average factory of three or four decades ago was usually little more than four walls and a roof, and even this poor shelter was provided probably more to protect the material in process of construction than from any humanitarian consideration for the workers themselves.

Fortunately, those days are over, and today the modern factory is provided with every possible means of comfort necessary to the welfare and efficiency of the employes. There are, however, many factories and plants where the old idea still clings, and it is to the owners of those plants that the message in this article is directed.

Consideration of the health and comfort of the employe is of paramount importance, not only from an humanitarian standpoint, but also from an economic one. At least one-third of an employe's time is spent at his place of work and too much attention cannot be paid to his health requirements. Such elementary requirements as good lighting, properly heated rooms, cool drinking water, clean lavatories, prevention of dust, etc., are even more important than many refinements of design and methods for securing high thermal efficiency from mechanical equipment.

Money spent in meeting the necessary requirements for the health of the worker should not be thought of as useless expense, but should be considered in the light of an investment. For the health and well-being of the workers will pay big dividends in increased production and in reduction of turnover charges.

Beginning in the current issue, Power Plant Engineering will publish a series of articles under the general heading of "Health Problems in Industry." These articles written by one of the most eminent public and industrial health authorities in the country are of timely interest and show not only the damaging effects of disregarding the health requirements of the workers but also point out proper corrective measures. They deal with a subject that no modern executive can afford to ignore.

Much May Be Learned from the Large Plant

It is frequently stated that the design of a large station is so radically different from the problems involved in laying out a small plant that a study of the large station, by the average engineer, is hardly warranted except as a matter of general educational interest. Off-hand this might seem to be true; but on closer analysis it will be found that, except for the magnitude of the project and certain added refinements which are possible, the fundamentals of design are the same whether the rating is to be 1000 kw. or 400,000 kw.

There is much to be gained by following the work of the large station, both from the design and the operating viewpoints. The magnitude of such projects call for the highest type of engineering ability and demand the most careful analysis of modern practice. As a result the big plant is usually the composite ideas of a large number of engineers and in the design certain trends of practice are definitely solidified.

For instance, from the plans of the Hudson Avenue station of the Brooklyn Edison Co., covered elsewhere in this issue, we learn that bleeder steam for feed-water heating is late practice; that the heat balance is to be taken care of with a special arrangement of a house turbine; that high voltage underground transmission is practicable; that a water rate of 10 lb. per kw.-hr. is possible and many other such points.

Much may be learned from the accounts of these vast power enterprises, which point the way for new and larger achievements in the power field. If your plant is small, that is little reason for lack of knowledge as to what is new and best in your chosen field of endeavor.

Feed Water Temperature

Superficially it would seem that to obtain the highest possible steam generating efficiency, the boiler feed water should be at a temperature as high as possible. Every heat unit added to the feed water before it enters the boiler relieves the boiler of just that much extra work and permits of a higher actual evaporation per pound of fuel burned. Heat for the feed water heater is derived from exhaust steam and where the exhaust would otherwise be going to waste, it is certainly desirable to utilize as much of it in this manner as possible. Where, however, condensing equipment is available and exhaust steam might otherwise be used to produce power, the question as to how much should be bled off for heating feed water is by no means a simple one.

In a paper on feed water heating for high thermal efficiency which he read recently before the American Society of Mechanical Engineers and which is abstracted on another page of this issue, Mr. Helander points out that in any plant having any arrangement of main and auxiliary units, condensers, economizers, etc., there is a particular feed water temperature that will give best efficiency and that this temperature need not necessarily be high. The question is considered as to its thermal aspects and the author has presented data and material that should be of exceeding interest and value to the engineering profession. No consideration has been given, however, to the subject of costs. Although the inclusion of this consideration would have entailed considerable complication in the solution of the problems given, it would have added greatly to the value of the paper, because in many cases it might have altered the results materially.

If I Were a Chief Engineer

Delegate to one power plant employe the combined duties of an executive, who hires and directs all men of the plant personally or through assistants, and those of a business man who buys supplies and fuel, draws up contracts for work, calculates costs and recommends the purchase of additional machinery, and add to these duties the work of an engineer who advises the owner on all technical points, draws up specifications for new machinery, inspects work of contractors, supervises tests and makes out the working schedule, and you have an idea of what I would want to do if I were the chief engineer of a power plant of moderate size.

There are literally thousands of just such men throughout this country of ours. These men are no longer tradesmen; they are seldom obliged to do manual labor. Every duty they have calls for brain power, the ability to reason correctly, the faculty of foreseeing results of existing or possible conditions, that power which induces others to think as they think.

So if I were a chief engineer, I would keep constantly in mind that I am dealing with men and machinery, that the laws governing one do not apply to the other, that my big problem now is to master the art of handling men. Nobody can expect to succeed in an executive position without the ability to get others to do what he wishes and to keep them happy in the doing.

If I were a chief engineer, I would not forget that my work is to guide and give counsel to others to secure safe and economical operation of the plant. Their success means my success, their failure my failure. It would behoove me to hire men who are sure to perform the work I assign to them as it should be done. I must therefore adopt some very definite rules in hiring men.

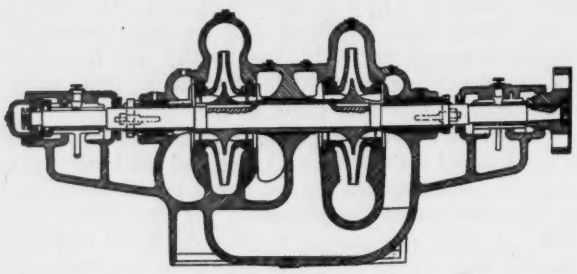
Once I get the most desirable men, I would want to hold them, so I would offer inducements such as advancements in positions through a proper sequence. To keep men contented, I would transfer them to work which was more agreeable to them. I would offer training courses to those ambitious to advance. I would establish grades of working conditions to accompany advancements in positions. My plant would offer a bonus to encourage higher economy and I would work out a very definite system of wage advancement.

Men who were not making good would be told so and in just what way they failed; this knowledge would be worth money to them. Men who had outgrown our organization would be helped to better positions outside. I would make my plant a place where the square deal was practiced rigidly.

And if I were a chief engineer, I would make my plant such a model that my executive and engineering skill would demonstrate my qualifications for a higher position, such as superintendent of a big plant or master mechanic of an industrial establishment. The chief engineer's position is a man's size job calling for broad experience and mature judgment in human nature, business transactions and technical engineering, and I would be proud to fill such a position successfully; but there are higher goals, and having attained this one, I would lay my plans to qualify for my next step.

Volute Construction Is Applied to Multi-Stage Pumps

WHERE pumps driven by motors of slow or moderate speeds must deliver water at pressures higher than are desirable or practicable for a single-stage pump, instead of using a single-suction multi-stage pump, two separate single-stage pumps are sometimes connected in series, so that one discharges into the suction of the other. This method has frequently been adopted, particularly in water works service. In medium and smaller sizes, the use of two independent pumps in series becomes somewhat more cumbersome, and a multi-stage pump is more often used. The length of shaft permissible in a multi-stage pump is limited because of the critical speed, and if many stages are employed, the designer no longer has a free hand in providing water passages of the shape and size conducive to the highest



NEW TYPE PUMP CONSISTS OF TWO OR MORE SERIES PUMPS IN ONE CASING

efficiency. Consequently, where more than three stages are required, the single suction impeller which occupies less space on the shaft than does the double suction impeller, and thus permits the use of a shorter shaft, is used.

It is impossible, however, to obtain as high efficiencies with a commercial multi-stage single suction pump as would be possible in a single-stage pump with double suction impellers, not only because of the less favorable limitations imposed on the impeller, but also because there is not sufficient space for an efficient volute diffusor and suitable return passages leading from the diffusor to the eye of the succeeding impeller. The De Laval Steam Turbine Co. therefore developed a new type of multi-stage pump, known as a "series" pump, in which the advantages of the double suction impeller are retained. This is made possible by the use of a specially formed casing which provides individual volutes for each impeller, with ample interconnecting passages within the casing itself.

This double suction impeller gives perfect hydraulic balance and two of the stuffing-boxes which would be required if two separate casings were employed are eliminated, together with their friction. As compared with a single suction impeller, the double suction impeller has a smaller suction eye, which permits of making the impeller itself smaller in diameter, and hence the pump can be built to operate at a higher speed for a given head and capacity, or for the same speed, head and capacity, a higher efficiency is obtained. Besides giving the highest efficiency, the volute type diffusor is superior to diffusion vanes, in that it is not subject to clogging or rapid wear, and it also gives a broader efficiency curve, that is, a higher average efficiency over a wide range of delivery.

The pump casing is made in two parts, divided on a horizontal plane passing through the center line of the shaft, the suction and discharge openings being in the lower part, so that they are not disturbed when the casing cover is lifted. Perfect form and smoothness in the suction and discharge chambers and the passages connecting the volute of one stage to the suction chamber of the succeeding stage is secured by the use of dry sand molds in casting the casing and cover.

Leakage from the discharge chamber of each impeller back to the suction chamber of the same impeller is prevented by the use of labyrinth wearing rings. One ring of each pair, known as the case protecting ring, is held in a recess formed in the casing and the casing cover. The other ring, known as the impeller protecting ring, is screwed onto the impeller. The intermeshing grooves of the labyrinth rings present a long and tortuous path to water leaking from the discharge to the suction chamber, thus greatly reducing leakage, while at the same time permitting the use of amply large running clearances. One proof of the effectiveness of this device in preventing leakage is the much longer life of such rings as compared with ordinary flat wearing rings.

To prevent leakage from the suction chamber of one impeller to the suction chamber of the succeeding impeller; that is, from stage to stage, the bushings where the shaft passes through the partitions between stages are made of ample length. The shaft is protected between the impellers and from the impellers to the outer ends of the stuffing boxes by bronze sleeves, and the pump case and cover by bushings at the partitions. Sufficient clearance is provided so that the shaft sleeve and the pump casing bushing are not in metallic contact.

This series design gives an efficiency curve which is remarkably flat, that is, a high efficiency is maintained over a wide range of delivery. This is obviously a great advantage, and distinguishes this type of pump from pumps in which diffusion vanes instead of volutes are used for converting the velocity of the water leaving the impeller into pressure head. In other words, the advantage in this respect of the single-stage volute pump is now extended to multi-stage pumps of two and three stages.

New Instrument Weighs CO_2 Gas

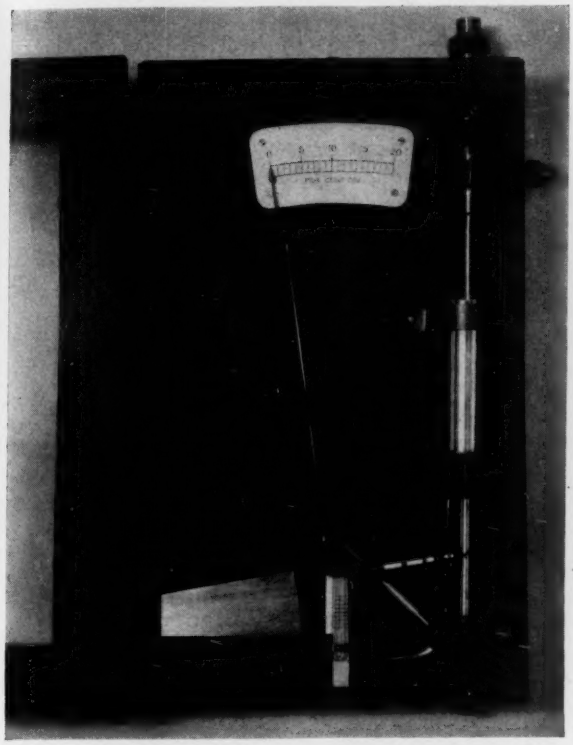
THERE HAS recently been placed upon the market a new type of CO_2 indicator, known as the Olsson gas balance. As the name suggests, the instrument is a purely mechanical device, the operation of which is based upon the differences in specific gravity between two gases.

As may be seen from the accompanying illustration, the machine is simple in construction, consisting essentially, of a beam supported by rustproof tempered steel knives upon agate bearings, to the left arm of which is attached a very light, air-tight metal float of about 1000 c.c. capacity. This float is counterbalanced on the right arm by adjustable brass weights.

Moving over a scale in the upper part of the case is the indicator, or pointer, a small metal tube open at the

upper arrow-shaped end, its lower end communicating with the "float" in such a manner as to allow air in the float to expand and contract according to changes in temperature and atmospheric pressure. This arrangement is made in order to prevent errors that otherwise would arise from such changes, were the "air float" hermetically sealed.

Gas is drawn from the flue by a substantially built common type water suction pump and delivered into a box enclosing the balance, wherefrom, after being weighed, it is removed by suction of the waste water.



THE OLSSON GAS BALANCE

It is obvious that if the balance is adjusted to point at zero, when the box is filled with air, the "float" will rise if a gas heavier than air, such as flue gas, is introduced. This fact, of course, is due to the difference in weight of the volumes of gases displaced by the float and the balance weights in comparison with the same volumes of air. These differences are great enough to cause distinct indications on the scale even in the case of a slight change in density of the gases.

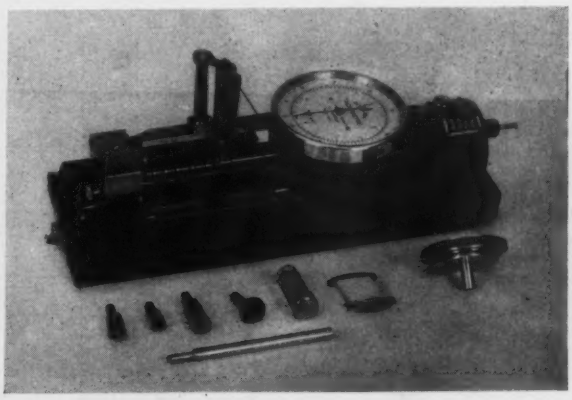
Flow of gas can be regulated and maintained constant at various rates, the velocity being indicated by the difference in the height of the oil levels in the U-tube.

When used as a CO_2 indicator, the apparatus is adjusted and calibrated so as to indicate correctly, within a margin of ¼ of one per cent the amount of CO_2 in the flue gas. The indications are not intermittent, but are an uninterrupted series of messages regarding the exact furnace conditions at all times. The indications are a few seconds behind the moment when the actual change in gas proportion takes place.

This machine is enclosed in an electrically welded iron case 5 in. deep, 12 in. wide, 20 in. high, and weighs 15 lb. The average consumption of water is about 10 gal. per hr., and this item represents the only cost of operation. The gas balance is made by the Olsson Corporation, of New York.

Tachometer Is Equipped with Curve Drawing Device

RECENTLY there has been placed on the market in this country a curve drawing tachometer or tachograph as it is called which has had wide use in Switzerland, where it is manufactured, and in other countries



GRAPHIC STUDY OF SPEED CONDITIONS POSSIBLE WITH THIS TACHOGRAPH

abroad. This instrument is a combination of the familiar dial type of tachometer combined with a curve drawing mechanism which not only shows the speed graphically but also marks off the time interval in units as small as 1/5 sec. It is also built in range of speeds from 30 r.p.m. to 24,000.

As shown in the illustration the feed of the paper strip is accomplished through two rollers driven by clock work. The upper roller carries a series of discs which ink in the parallel longitudinal lines. It is possible by calibration to place these discs so that the scale lines agree exactly with the graduations on the dial. After the test the operator usually marks the speed on the parallel lines of the chart in accordance with the particular speed range which is in use.

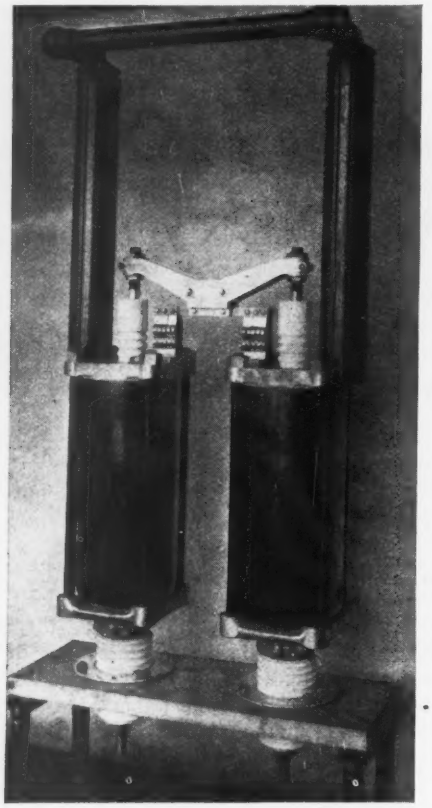
It will also be noted from the illustration that there are two pens, one of which draws the speed curve and another which marks the time interval by a series of dashes. The entire width of the paper strip is available for the curve drawing pen for each of the speed ranges which may be used. These ranges are controlled by a thumb slide and should the pen start to move off the paper, a gear shift causes the pen to operate on the next range which will be within the limits of the strip.

On account of the wide range possible, it is said that speed variations of one 1 or 2 per cent can be made to show up as readable curves and this together with the small time interval marks, permits the study of fluctuation such as those caused by regulation of governing apparatus, shut down and starting characteristics of motors and other such applications.

These instruments are to be distributed by O. Zernickow, of New York, N. Y.

Improved Circuit Breaker Eliminates Oil Throwing

TO ELIMINATE the throwing of oil and the danger of secondary explosions from gas in circuit breakers the General Electric Company has recently added some important improvements to the construction and design of its line of oil circuit breakers for indoor use, known previously as the FH-3, FH-6, and the FH-9 breakers. These improvements consist of the addition of an oil and gas tight cap on the oil vessel, a stuffing-box around the contact rods in the upper insulators, and separating



TYPE FH-209 OIL CIRCUIT BREAKER, 15,000 V., 800 AMP.

chambers leading from the top of the oil tank. The interrupting capacities of the improved breakers are as follows: Type FH-203, 14,000 amp. at 15,000 v.; FH-206, 20,000 amp. at 15,000 v., and the FH-209, 30,000 amp. at 15,000 v.

The operation of the improved breakers is as follows: When the breaker is opened under load, the arc is interrupted below the lowest baffle in the oil tank. The gas that is generated, mixed with some oil, passes upward through the center hole in this baffle into the next compartment. In passing through the next baffle, the gas and oil are partially separated, the complete separation taking place in the separating chamber, from which the oil returns to the tank, and the gas, passing through the separating chamber is cooled, and passes out through a system of pipes to a general outlet. This outlet should be connected to a switch house header leading out of doors, so that the gas will not be liberated in the switch-house.

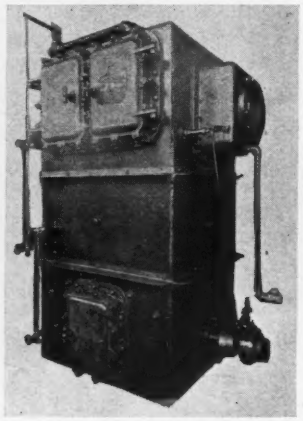
In addition to the changes mentioned, the new type breakers are equipped with heavier rods for holding on the oil tank caps, heavier baffle construction, and in some cases, heavier contact rods.

Feed Water Heater Shell Built of Wrought Iron

TEMPERATURE differences in the various parts of a feed water heater being unavoidable, the shell is subjected to more or less strain from unequal expansion.

Under ordinary operating conditions, the universally used cast-iron shell construction should meet this condition without signs of weakness, but leakage at the joints and even cracking of cast-iron shell plates sometimes result from exposure to excessive temperature differences.

Wrought iron, being much stronger than cast iron, offers a logical improvement over the latter for the shells



SEAMS ARE BUTT-WELDED IN THIS WROUGHT-IRON HEATER SHELL

of heaters in which there are sudden changes of temperature between the hottest and the coldest water entering.

For this reason, Warren Webster & Co. of Camden, N. J., has recently added wrought iron shell heaters to its line of feed water heaters. These heaters are recommended as affording greater safety than cast-iron shells, especially where low volume constant steam flow is combined with intermittent pumping and introduction of cold water. The wrought-iron construction is also a better protection against careless operation, as for instance, where the attendant forgets or fails to drain the cold water from the heater on starting.

These heaters, as shown in the illustration, are of the rectangular vertical pattern except for the largest capacities which are of the horizontal cylindrical type.

In the construction of the shell genuine wrought iron is used which is made by the puddling process. This is the same material that is so widely used in the manufacture of water pipe for boiler-feeding as well as for industrial and domestic services.

Seams between the heater shell sections are butt-welded, the metal being fused into the corners to make a

rounded joint. Suitable bands of angle or tee iron, or stay-bolts are provided where necessary to stay the shell against pressure which would tend to deform it. Riveted construction is employed for the cylindrical heaters of larger capacity.

Wrought-iron heaters of standard construction are guaranteed against damage due to unequal expansion and to withstand pressures up to 10 lb. per sq. in. (normal test pressure 15 lb. per sq. in.).

Pemigewasset River Development Is Under Way

PRELIMINARY work for the construction of the power plant of the Utilities Power Co. of Meredith, N. H., in the towns of Bristol and New Hampton, N. H., has been completed. Construction of the transmission lines is already well under way and with the opening of the ground early in the spring, the actual construction of the concrete dam across the Pemigewasset River at the up-stream end of Ayer's Island will be started. The power project is the largest undertaken in the state of New Hampshire in many years and although the initial development will be only 7500 hp. the ultimate rating

FIG. 1. COFFER DAM ABOVE AYER'S ISLAND DIVERTS WATER INTO MAIN CHANNEL.—POWER HOUSE WILL BE BUILT AT THIS POINT

of the two plants which are to be built will probably be 35,000 hp.

With the development of plans for the first unit of the power project are two secondary developments, one of which will be available by increasing the height of the dam at any time desired and the other by the location of a second plant a short distance below the site of the first dam at a site already secured by the company and available at the company's option.

According to present plans the dam will be approximately 620 ft. at the crest, 50 ft. in height with flashboards giving an additional 5 ft., with a spillway section 300 ft. in length. The dam will be so constructed that it may be raised to 83 ft. in height. The pondage available at the 55-ft. height will be approximately 100,000,000 cu. ft. and when raised to 83 ft, 200,000,000 cu. ft. will be added. The drainage area is approximately 760 sq. mi.

Exclusive of Asquam Lake, and based upon estimates and revised measurements made by the United States Government at Plymouth, N. H., and based upon the 55-ft. dam, the following power will be available:

	Hourly horsepower	10-hr.-hp. available
Minimum power 24 hr. based on monthly mean flow	2,600	6,240
95 per cent of time	3,000	7,200
90 per cent of time	3,300	7,920
80 per cent of time	3,800	9,120
70 per cent of time	4,300	10,320
50 per cent of time	5,700	13,680

An Ambursen type dam will be used, impounding, with a 3-ft. draw down, available storage of 100,000,000 cu. ft. With the dam raised to 80 or 83 ft., trebling the volume impounded, and the equipment correspondingly increased, a capacity of 12,000 hp. will be made available. With the diversion dam already mentioned, and

FIG. 2. MAIN CHANNEL OF PEMIGEWASSET JUST BELOW SITE WHERE DAM WILL BE LOCATED

by construction of a canal and penstocks, the additional plant will have a capacity of 7000 hp. additional. With the plant developed to the fullest and use made for storage on the nearby tributaries of the Pemigewasset River, it is estimated that 35,000 hp. can be installed.

As laid out the initial power house will be of concrete and brick, 90 by 40 ft., fireproof construction and will be equipped with water wheels of the S. Morgan Smith vertical type, three units of 2500 hp. each, operating under 55 ft. head. These will be so constructed so that when the height of the dam is raised to 80 ft. each unit will furnish 4400 hp. The generators will be furnished by the Westinghouse Electric & Manufacturing Co., three units of 3500 kw. each, 257 r.p.m., with direct connected exciters and directly coupled to waterwheel shafts.

Officers of the Utilities Power Co. are: President, Herbert B. Rust, Meredith, N. H.; treasurer, Bertram Blaisdell, Meredith, N. H.; clerk, Frank R. Prescott, Meredith, N. H.

Ohio Companies Plan to Tie Power Systems Together

WORK IS to start shortly on a $7,500,000 construction program which will link Cleveland electrically with power systems as far south as the Ohio River. This was seen by Robert Lindsay, president of the Cleveland Electric Illuminating Co., as the most significant aspect of the contract entered into with the Northern Ohio Traction & Light Co., with headquarters in Akron.

Under the terms of the contract, which is of long time nature, the Cleveland and Akron companies agree

to exchange electricity when and as needed up to 25,000 kw.

This contract, under which Cleveland will get power from the N. O. T. stations in case there were a breakdown here, is one of several to be negotiated. The plan is to complete arrangements under which generating plants over a large area will be so interconnected that in emergency the others can be drawn upon for power.

"But this contract is only a part of the plans of the Illuminating company to expand its facilities to meet the expected industrial growth of Cleveland within the next two years," Mr. Lindsay said. The first work of the Illuminating company will be that of building high tension lines from the E. 70th street station, which is the company's main generating station. This plant, which has a 208,000-kw. capacity, is to be equipped with additional generating apparatus to raise the capacity to 263,000-kw. Of the 55,000-kw. increase, 25,000 will be for the N. O. T. and the rest for the anticipated increase in Cleveland. This machinery and the high tension lines which, within the city will be underground, are to be installed and in operation by Oct. 1. The current for down state transmission will be of 132,000 v. Cleveland shortly will have a direct connection as far westward as Toledo and as far southward as Mansfield, O., Zanesville and Bridgeport and as far eastward as Pittsburgh.

Federal Power Commission Report

REVIEWING THE work of the Federal Power Commission during the two years of its existence, indicates the practical value of the water power act and the task now confronting the commission. Due to the delay in securing adequate Federal legislation, a flood of applications followed immediately upon approval of the act. During the second year, applications aggregating a net total of 5,000,000 hp. of proposed installation have been filed with the commission. This, added to the applications of the preceding year, makes a total of 321, involving in excess of 20,000,000 hp., more than twice the existing water power installation of the United States, and more than six times the aggregate of all applications for power sites under Federal control in the preceding 20 yr.

Nearly one-half of the aggregate of 20,000,000 hp. is represented by applications upon the St. Lawrence, Columbia and Colorado Rivers, upon which, in general, action has been suspended. The St. Lawrence involves international relations and may require a treaty before action can be taken. The Columbia has been under investigation by a special board to determine, before applications are approved, the relation between water power, irrigation, and navigation upon that stream. Action on the Colorado River is awaiting the findings of the Colorado River Commission, an organization authorized by act of Congress for the purpose of negotiating, between the States within the Colorado basin, a compact in accordance with which the waters of the river may be apportioned among these States.

On more than half of the applications filed during the two years, the commission has been able to take final action. The development of hydroelectric power involves large outlays of capital, and the successful development of water power requires a high degree of training and ability in handling its financial and technical problems. Of this, many applicants seem not to be aware. The result has been to put a burden of investigation upon the commission in order that it might not grant rights where there is little probability that the projects can be financed and constructed.

Up to June 30, 1922, the commission had authorized 58 preliminary permits and 49 licenses, of which 18 were for transmission lines. The 58 permits now outstanding involve an estimated installation of 2,405,975 hp. and the 31 licenses for power projects, 1,945,245 hp., or a total of 4,351,220 hp. Of the projects covered by the 31 licenses, 27, involving an estimated installation when completed of 1,951,800 hp., were either completed or under construction at the close of the fiscal year. This is 30 per cent more than was constructed under Federal authorization in the 20 yr. preceding the passage of the Federal water power act.

City of San Francisco to Build Power Line at Once

CONSTRUCTION of a transmission line, to bring to San Francisco the hydroelectric power generated at the Moccasin Creek power plant of the Hetch Hetchy project, will begin within a few months, following the receipt by the Board of Public Works of bids on wire for the line. The wire alone, it is estimated by City Engineer M. M. O'Shaughnessy, will cost approximately $1,000 000.

The entire transmission system will necessitate the expenditure of nearly $5,000,000, which will include the construction of steel towers, rights of way, and a distributing station. Bids for this work will be received within a few weeks.

The calling for bids was the first indication that the city had decided definitely to construct its own transmission line at the present time. For a time it was thought the power would be sold wholesale at the Moccasin Creek plant to one of the power companies for distribution.

During December more than 2000 men have been engaged on the Hetch Hetchy Dam and all labor conditions are operating in a more satisfactory manner than previously, according to Mr. O'Shaughnessy. He states that on the mountain division of the Hetch Hetchy dam proper 96 per cent of the concrete structure has been completed. This includes 11,080 cu. yd. of concrete placed in December, 1200 yd. of which is included in the tunnel and shaft lining.

May Turn Texas Gas to Power

UTILIZATION of the natural gas of the Amarillo, Texas, field for generating electricity on a scale of great magnitude is being considered by large financial interests, according to S. J. Keese, an engineer of Los Angeles, who has been investigating the available gas supply of the existing wells and the cost of the proposed electric project. It is stated that there is now a production of 1,000,000,000 cu. ft. of gas a day from 27 wells that are scattered over the proved territory of 1200 sq. mi. in the Panhandle of Texas.

Mr. Keese's surveys have had in view the feasibility of using natural gas for generating sufficient electric power to operate the trains of the Atchison, Topeka and Santa Fe, between Kansas City and Albuquerque, N. M. It is stated that the Santa Fe is favorably inclined to the proposition, provided the power cost is not too great. While Mr. Keese's figures are not as yet available, it is

known that with natural gas so abundant and cheap the initial cost of electric power will not be much in excess of that derived by hydroelectric means.

Foreign and American Turbo Generator Practice Are Compared

IN COMMENTING on foreign turbo-generator practice as compared with American methods, F. D. Newbury of the Westinghouse Electric and Manufacturing Co., in an address before the Electrical Institute of Washington, pointed out that such companies as Metropolitan-Vickers, England, Brown-Boveri, Switzerland, and A. E. G. of Germany build 25,000 kv.a. units in single-phase and two-phase types. Units above this size and up to 50,000 kv.a. with 3 and 4-phase windings, are considered quite unusual. In this country, according to Mr. Newbury, units of 50,000 to 62,500 kv.a. are now accepted practice and are built in either 3 or 4-phase windings. Such machines with a modern type of boiler equipment, with steam at a temperature of 700 deg. F. and a vacuum of 29 to 29.5 in. will show a water rate of 9.5 to 10 lb. per kw. hr. and a coal consumption of from 1.25 to 2 lb. per kw. hr. At the high temperature of operation Mr. Newbury pointed out that the turbines will glow a dull red under the enamel.

FEW LARGE UNITS BUILT ABROAD

TO SHOW A comparison between the size of units used here and abroad Mr. Newbury stated that the Westinghouse organization had built more than 100 units of 15,000 kv.a. and up while Metropolitan-Vickers had built only 11 such units. Two of the 62,500 kv.a. units are to be installed in the new Hudson Ave. station of the Brooklyn Edison Co. one of which will be built by the General Electric Co. and the other by the Westinghouse Co. Many 37,500 kv.a. units are now in service and units of this size are ample to meet the needs of stations of 20,000 kv.a.

Mr. Newbury went on to show that the essential difference between the foreign turbo-generators and those built in American practice were in such points as frequency, ventilation, method of coil winding, and rotor construction. While 25 and 60-cycle units are practically standard here, a frequency of 50 cycles is quite common abroad. Three methods of ventilation are in use, known as the circumferential, radial and axial types. The Brown-Boveri method is to an adaptation of the circumferential type in which air is forced through ducts at the back of the rotor. In 1912 the axial system began to find favor in American practice and has been used quite extensively during the past 10 yr. for large machines. The same system is used quite widely abroad. Coil winding practice in Germany is tending to follow along the lines of American design although both radial and parallel slots are used. Mica insulation for rotors is now practically standard practice in foreign countries and the use of mica for stator insulation is now in general use as it is in this country.

BUSINESS GOOD IN TURBINE FIELD

IN COMMENTING on business conditions Mr. Newbury stated that the year 1922 was a banner year in the turbine business with practically all companies producing their maximum output. He asserted that the hazards in this condition lies in the fact that the volume of these orders might be completed in 1923 and make 1924 a year of stagnation similar to 1921. In this connection it was also pointed out that since 1906 the turbine business had progressed by a series of peaks and depressions, with 3 yr. as the average length of each period. For the year 1916 the Westinghouse Electric & Manufacturing Co. considered 200,000 kv.a. a good volume of business while in 1919, 600,000 kv.a. was felt to be satisfactory. In 1922 the turbine installations amounted to almost 1,000,000 kv.a.

High-Temperature and High-Pressure Steam Lines Discussed by A. S. M. E.

AT A MEETING of the Metropolitan Section of the A. S. M. E., held at the Engineering Societies Building in New York on Jan. 4, B. N. Broido, consulting engineer for the Superheater Co., presented his paper on High-Temperature and High-Pressure Steam Lines, which had been presented by title only at the annual meeting of the society in December. The paper, which is available in printed form, presents for the first time in English the results of various authoritative German tests on this subject, and adds further results and deductions from the American experience of the author. Treatment of the subject is under four main heads—radiation losses and pressure drop in superheated steam lines, the best steam velocity, particularly for high-pressure lines, and other considerations in the design of either high or low pressure lines for transmission of superheated steam.

Discussion developed along somewhat technical lines, and showed divergence from the point of view of the author in several details, but the value of his paper as a summary of material hitherto not readily available was generally conceded.

G. A. Orrok, consulting engineer, commended the paper for emphasizing the importance of radiation from the outside surface of pipe. In common with several other speakers, he commented on the fact that higher velocities than 10,000 ft. per min. are often employed.

L. B. MacMillan, consulting engineer for Johns-Manville, Inc., discussed the relative rates of heat transfer from saturated and superheated steam to a surface, showing that the transfer is more readily accomplished in the case of saturated steam than with superheated steam. He said that the preferred method of calculating pipe sizes nowadays is on the basis of pressure drop.

Pressure drop in steam lines, said J. H. Lawrence, Secretary of the Power Division of the society, is a very important subject and one about which comparatively little is known. Trustworthy data for designing steam lines is not available, and design has been largely based upon guesswork. Various types of fittings have been devised, but the designs are lacking in logical basis. Mr. Lawrence cited the case of the Hell Gate Station, where the actual loss proved to be only about one-half that given by the formulas, although only standard fittings were used. In this case, the most serious loss occurred where a loop had to be installed to take care of expansion. Mr. Lawrence further pointed out that steam velocities of 15,000 ft. per min. are used ordinarily in big stations, and 20,000 ft. per min. is employed if necessary. The minimums of 6,000 ft. per min. for saturated steam and 10,000 ft. per min. for superheated steam, as given in books, he considered misleading. As pipe sizes increase, a corresponding increase in the allowable velocity is admissible.

News Notes

SEPARATION OF THE two divisions of the Ohio Body & Blower Co. was accomplished Jan. 1, by the organization of the Swartwout Co. D. K. Swartwout, who for years was president of the former company and its parent, the Ohio Blower Co., now is president of the new organization. Other officers of the Swartwout Co. are W. M. Pattison, president of the Pattison Supply Co., and D. K. Swartwout, Jr., vice-presidents, and W. E. Clement, secretary and treasurer. Mr. Clement has been secretary of the Ohio Body & Blower Co. The Swartwout Co. will continue the manufacture of its ventilators, core ovens, enameling ovens, metal buildings, and the steam line, including exhaust heads, steam and oil separators, steam traps and feed water heaters.

CHAIN BELT Co., Milwaukee, announces the appointment of Fitch S. Bosworth as manager of the Chicago office. Mr. Bosworth has been in charge of the Chain Belt Co.'s St. Louis office for the last 3 yr. and has specialized on chain and conveying engineering problems. With him will be associated Raymond X. Raymond, who for several years has been connected with the Export Sales Department in Milwaukee. Thomas F. Scannell, formerly of the Chicago office, has been placed in charge of the St. Louis office.

ELLIOTT Co., of Jeannette, Pa., announces that it is now handling both the sales and manufacturing of Lagonda grease extractors and Lagonda double automatic and non-return valves, formerly products of Elliott Co.'s associate, the Lagonda Manufacturing Co., of Springfield, O. This change is only significant from a sales standpoint, as both the engineering and manufacturing of these lines of products have been handled at Jeanette for the past 4 or 5 yr.

FIRE WHICH THREATENED to destroy the entire structure of the Eagle Rock sub-station of the Southern California Edison Co., Los Angeles, was extinguished after burning almost eight hours. The damage was unofficially estimated at $500,000. The fire was caused by an explosion of a 60,000-v. lightning arrester and the flames quickly spread to 160,000 gal. of oil stored at the substation.

UEHLING INSTRUMENT Co., Paterson, N. J., has appointed the Mine & Smelter Supply Co., of El Paso, Texas, as its exclusive representative for CO_2 recording equipment and other power plant recording instruments in the States of Arizona and New Mexico, and West Texas, as well as in the Republic of Mexico, north of Mexico City.

GEORGE BLAIR, JR., assumed the duties of manager of the New York office of the McClave-Brooks Co. on Jan. 1. In addition to these duties he retains his position as manager of the Philadelphia office of this company.

EDGAR J. KATES is now chief engineer for the De La Vergne Machine Co., of New York City, in charge of oil-engine design and engineering.

FOLLOWING the 11 per cent reduction of rates of the Pacific Gas and Electric Co., the State Railroad Commission recently announced a similar cut of approximately 10 per cent in the rates of the Great Western Power Co. The reductions in both instances are practically identical and are new and take the place of the existing rates and surcharge. In the case of the Great Western Power Co., the rate structure eliminates various discriminatory rates, and for that reason the percentage of reduction is not uniformly applicable to all present charges, the decision sets forth.

COMBUSTION ENGINEERING CORPORATION, of New York City, announces the acquisition of the Quinn Oil Burner and Torch Co. W. R. Quinn, former president of the Quinn Oil Burner and Torch Co., becomes associated with Combustion Engineering Corporation, as manager of its Fuel Oil Department.

GRANBY CONSOLIDATED Mining, Smelting & Power Co. is constructing an addition to its power plant at Anyox, British Columbia, and will install a 5000-hp. 370-ft. head, vertical reaction turbine, designed by the Pelton Water Wheel Co., which is to be built at the works of its associated company, the Dominion Engineering Works, Ltd., of Montreal.

FIRST CONSTRUCTION on the San Joaquin Light and Power Corporation proposed Kings River hydroelectric project will begin immediately. The building of a permanent transmission line from Piedra to the site of the proposed Balch power-house at the juncture of the north and west forks of the stream will constitute the first step. It will be 22 mi. in length and of aluminum wire carried on steel towers. The cost has been estimated at $170,000.

CONSTRUCTION WORK on the power house at the Don Pedro dam in the Sierra Nevada mountains back of Turlock, was completed recently with the pouring of the cement for the roof. When in full operation the power plant will generate 27,000 hp.; there are three units of 9000 hp. each in the plant, each unit consisting of a turbine, a generator, three transformers, an oil switch, a potential transmission and lightning arrester. Power generated at the dam will be distributed to the Turlock and Modesto districts. The city of Turlock is trying to buy power from the plant to distribute it under city management.

U. S. CIVIL SERVICE COMMISSION announces examinations, March 7, for junior engineer, junior physicist, and junior technologist to fill vacancies in the Bureau of Standards, Department of Commerce, for duty in Washington, D. C., or elsewhere, at $1200 to $1500 a year, and in positions requiring similar qualifications, at these or higher or lower salaries. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. Competitors will be rated on general physics, mathematics through calculus, practical questions on each optional subject chosen, education, training, and experience. Apply for Form 1312, stating examination title.

U. S. CIVIL SERVICE COMMISSION announces an examination, March 21-22, for laboratorian to fill vacancies in the Federal classified service throughout the United States, including the Departmental Service, Washington, D. C., at $1,200 to $1,500 a year, or higher or lower salaries. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. Competitors will be rated on mathematics (through trigonometry), elementary physics, an optional subject, education, training, and experience. Applicants

must have reached their eighteenth but not their forty-fifth birthday on the date of examination. These age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating examination title.

Book Reviews

ENGINE ROOM CHEMISTRY, by Augustus H. Gill. Third edition, 174 pages, 49 illustrations; 5½ by 8, cloth; New York.

It is the object of this book to enable the engineer or engineman to gain some familiarity with the properties and behavior of the substances, as fuel, water, and oil, in which he is vitally interested. No previous knowledge of chemistry is required.

This book will give the engineer information on the determination of lubricants required for his own purposes and on the analysis of flue gas. He will know the quality of the fuel he buys and how to neutralize the scale-forming materials in feed water.

It includes chapters on the following subjects: Introductory Apparatus and Chemicals; Fuels and Their Analysis; The Regulation of Combustion; Gas Analysis; Water; Boiler Scale; Pitting and Corrosion; Mineral Oils; Animal and Vegetable Oils.

MECHANICAL WORLD YEAR BOOK—1923; size 3¾ by 6 in., 348 pages, cloth; Manchester, Eng., 1923.

In this, the latest edition of the Year Book, attention is called to the new section on fan work. Valuable data is presented on the subjects of ventilation, air conditioning, humidification, air passages, pressure losses in duct work, removal of dust and fumes, cupola blast, mechanical draft, etc. Several useful tables have been included. The section on safe loads and deflection of beams has been largely rewritten and new illustrations have been added. The notes on belting (leather, canvas, rubber and steel) have been somewhat enlarged.

Data is given on the general subjects of steam engines and turbines; boilers; gas, oil, and Diesel engines; gas producers; properties of metals; structural iron and steel work; shafting; gearing; bearings; belting; lubrication; hydraulic work; piping; fan work; and castings. Numerous general tables are included, such as logarithms and trigonometrical functions.

THE 20TH CENTURY GUIDE FOR DIESEL OPERATORS, by Julius Rosbloom and Orville R. Sawley; 636 pp., numerous illustrations and tables.

Leading up through a discussion of technical terms used, the theory of combustion engines, formulas used, and the principles of Diesel operation, the authors devote most of the book to practical matters, including questions and answers on operation, fuel feed, ignition, construction, accessories, low compression engines, compressors, pumps and batteries.

In descriptions of engines, it covers important English and American makes, including such recent developments as the McIntosh & Seymour, Worthington Solid Injection, Standard, and Sperry's compound marine type, as well as the longer established makes. An interesting chapter is devoted to Diesel-electric propulsion for ships, giving an analysis of the method and details of various systems in use.

Low compression or semi-Diesel engines are given careful explanation, some of the makes included being the Ingersoll-Rand, De La Vergne, Fairbanks-Morse, and Mietz and Weiss.

Requirements of air compressors, mechanical detail and capacity, and fundamentals for pump and battery equipment and operation are clearly brought out.

Altogether it is a pleasing as well as useful book. Well gotten up, easily read and understood, showing a thorough knowledge of the subject by the authors and containing numerous valuable facts and suggestions. It is worth owning if one has or expects to have to do with Diesel engines.

Catalog Notes

BULLETIN NO. 406, recently issued by the Louis Allis Co. of Milwaukee, Wis., is devoted to a description of the company's Type H D motors.

CELITE PRODUCTS CO., of New York, has issued a 62-page catalog entitled "Insulation of Oil Refinery Equipment," showing how Sil-O-Cel heat insulating products are used in the oil industry.

A BOOKLET entitled "Synchronous Motors for Ammonia Compressor Drive," setting forth the advantages of electrically driven ice plants and showing photographs of installations in ice making and refrigerating plants, packing houses, and allied industries, has recently been issued by the Westinghouse Electric & Manufacturing Co.

UNDER THE TITLE "Plant and Products," the De Laval Steam Turbine Co., of Trenton, N. J., has published a 24-page booklet, briefly describing the single and multi-stage steam turbines, centrifugal pumps, blowers and compressors, and speed-reducing gears in which that concern has specialized since its establishment in 1901.

G. M. DAVIS REGULATOR CO., of Chicago, is distributing its new catalog No. 10, giving the details of its line of valve specialties for automatic regulation of pressure. Besides going into the design features and operating details of all the valve specialties, there is also a section devoted to a few of the interesting installations made by the Davis organization, such as the Chicago Theater, Conners Creek power station, Union Stock Yards, and others. Charts for computing steam and water pipe sizes are also shown.

UEHLING INSTRUMENT CO., Paterson, N. J., has just issued a 12-page folder which explains concisely the two losses in the steam power plant, namely, the loss in steam turbine economy due to air leakage into the condensing system, and the sensible heat in the flue gases lost up the chimney. A table gives data on steam turbine economy as related to the absolute back pressure. The Uehling combined barometer and vacuum recorder, as illustrated in the folder, is in effect an automatic log of condenser performance, because it records the existing vacuum as well as the absolute back pressure for every second of the day. Data on combustion are given in another table, such as the variation of the chimney loss with the percentage of CO_2 and its relation to flame temperature and ratio of air to fuel supply. The Uehling CO_2 recorder and indicator are illustrated and twelve different kinds of important information which these instruments furnish are cited.

LINK-BELT Portable Loader Catalog was recently issued by the Link-Belt Co., Nicetown, Philadelphia, Pa., embracing the company's entire line of portable equipment. The book is the most up-to-date and complete ever issued by the company. It is 8½ by 11 in. and contains complete specifications of all of the standard machines which include the large one-man power swiveling loader, the portable belt conveyor, the standard type "A" machine for anthracite coal, and the "CS" loader for handling sand and gravel.

IMPORTANCE OF PROTECTING pipe against internal corrosion is shown in bulletin No. 3C, recently published by the National Tube Co., of Pittsburgh, Pa. Since the importance of reducing the oxygen content of water is becoming generally recognized as one method of meeting the corrosion problem in iron and steel pipes, this bulletin will be found of interest because of the complete way in which the subject has been covered. Not only is the theory of corrosion presented but also methods which are used to combat it, and results which have been obtained are discussed.

"STORING COAL SAFELY" is the title of a bulletin which has recently been issued by the Protectometer Co., of Jersey City, N. J. A summary is given of the factors influencing safe coal storage and some of the causes of spontaneous combustion are discussed. The bulletin then goes on to describe the Protectometer system of checking the temperature of the coal pile at various depths to determine whether the critical temperature is being approached. A type of automatic signaling device is also illustrated which may be driven into the coal pile and which will signal when the temperature reaches 150 deg. F.

"FEED WATER HEATERS in Their Relation to Steam Plant Efficiency" is the title of a 60-page booklet distributed by the H. S. B. W.-Cochrane Corporation, of Philadelphia. The text matter is not primarily descriptive of apparatus, but rather a presentation of the theory and practice of boiler feed water heating. After showing that the most efficient steam cycle is the one in which the feed water is heated from hot well temperature to boiler temperature by the use of steam withdrawn during expansion, various practical forms of apparatus and their uses are taken up, including vacuum deaerating heaters, back pressure heaters, heaters in conjunction with make-up water evaporators, feed water heating by stages, different methods of control for securing continuous heat balance, heaters in connection with exhaust steam heating systems, heaters in conjunction with hot water heating and service systems, including heaters operated at temperatures below 212 deg. F., combined heaters and softeners and combined heaters and feed water meters.

SEVERAL CIRCULARS have been issued by the Reading Steel Casting Co., of Bridgeport, Conn., describing its new line of cast steel valves. Circular No. 2 shows the new Pratt & Cady bronze union bonnet renewable disc globe and angle valves, while circular No. 3 describes the bronze regrinding union bonnet globe and angle valves which they have been building for about a year. It is stated in the bulletin on cast steel valves that the line has been designed for 350 lb. working pressure at a total temperature not exceeding 800 deg. F. or 500 lb. working pressure at a total temperature below 100 deg. F. Circulars No. 1 and 4 are new pieces of literature on the old and well established lines which are put out by this organization.

"HAGAN REGULATION" is the title of a bulletin which has been issued by the Hagan Corporation, of Pittsburgh Pa., which goes into considerable detail on the company's system for controlling combustion. This scheme of regulation depends on a master regulator which operates in accordance with the steam demands and controls all breeching dampers and also actuates a Roto reciprocating valve which controls the stoker engine. In addition, however, there is a combustion controller on each furnace which can be set to maintain a predetermined furnace suction by adjusting the air supply to the respective fuel beds in accordance with the resistance of each fuel bed. Numerous diagrammatic layouts are presented of different types of boiler plants, both stoker and hand fired which show how the scheme of regulation is applied. There is also a discussion of the value of such control as an aid to efficient combustion.

CASH STANDARD pressure reducing and regulating valves, special relief valves and valve specialties are described in a 30-page bulletin which has been issued by the A. W. Cash Co., of Decatur, Ill. As pointed out in this bulletin, the general action of the pressure reducing and regulating valves is basically the same whether the valve is assembled for steam service or for use with any other fluid or gas. Steam at initial pressure entering the regulator on the inlet side passes through a strainer which precipitates all but the finer particles of foreign substance to a sediment chamber. It then flows through a series of inlet ports. passes on through the seat opening, through the diaphragm chamber and through the outlet side into the delivery or working pressure line. Many similar details are covered in this bulletin with sectional views which show the operating features.

BULLETIN No. 302 issued by the Power Specialty Co., of New York City, takes up the advantage of using superheated steam and goes on to describe the line of Foster superheaters. In this 35-page bulletin, the section on the radiant heat superheater is of particular interest as this is a comparatively recent development; however, the line of U-shaped tube superheaters are also shown in detail together with installation views. In the radiant heat type, the superheater section becomes a part of the furnace wall either at the front or the back and is exposed directly to the radiant heat of the fire. Advantages which are pointed out for this type of superheater are that it is absolutely independent of the boiler and will not interfere in any way with any system of baffling which may be desired. Furthermore, it is possible to obtain a high degree of superheat in a limited space due to the high rate of heat transfer by direct radiation. It is also said that the maximum superheat is obtainable throughout the economical ranges of load without the same tendency for rise in temperature under peak load operation, thus making a higher average superheat available during the total time of operation. Other advantages are given, test data are presented and details of construction shown.